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Irrigation Works in the Hawaiian Islands.

By M. M. O'SHAUGHNESSY,* M. Am. Soc. C. E.

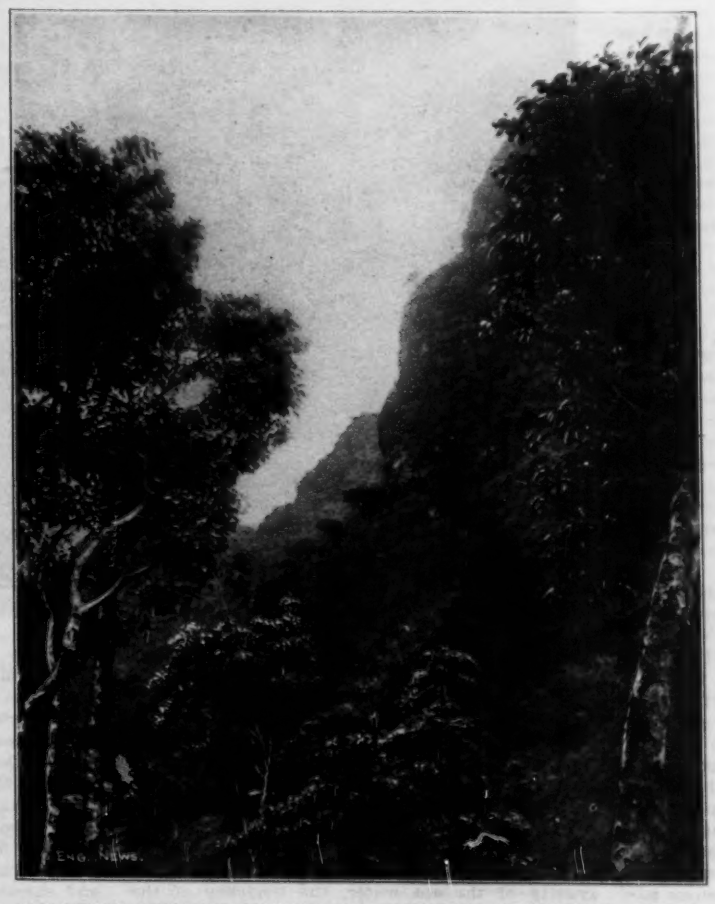
The development of irrigation projects in the Hawaiian Islands has been prosecuted with the greatest vigor by private corporations owning sugar estates during the last ten years. No aid for this work has been received from either the local Territorial Government of Hawaii or the National Government at Washington. What was formerly arid and unproductive soil, covered by wild brush and pasturing a few cattle, has been converted into productive sugar-cane land, by the application of water at a heavy expenditure of money and enterprise.

RAINFALL.—The rainfall of the Hawaiian Islands is very local and peculiar in its distribution. The trade-winds blow off the ocean from the northeast, and on this slope a rainfall of from 60 to 200 ins. per annum is quite common, the intensity varying with the altitude and local configurations, while on the lee sides the rain is often as light as from 5 to 15 ins. The Islands, as a rule, are quite rugged, varying in altitude at their central highest points from 3,000 to 10,000 ft. The windward sides are covered with a dense brush, which remains green throughout the year. The front page engraving and Figs. 1 and 2 give a good general idea of the mountain scenery. On the northeast slope of Maui the maximum precipitation occurs at an altitude of 1,500 ft., being often as much as 400 ins. per annum at Nahiku, while at sea level and higher up the mountains it is only one-third of this quantity.

USES OF WATER.—Water is used for irrigating the sugar cane, the annual crop of sugar each year amounting to 500,000 tons, which averages $70 a ton, or $35,000,000. One-half of this product is due to the development of irrigated plantations during the last twenty years. The remaining 250,000 tons are raised on rainfall plantations, which are very uncertain in their output, owing to the precarious rain conditions prevailing.

ANCIENT WATER RIGHTS.—The remains of old houses and fields bear convincing testimony that the population of Hawaii was very dense in prehistoric times. Nearly all the streams were led out by ditches called "auwais," and the water was used for growing "taro," the national food, and other vegetables. The ditches were excavated in surface earth and maintained by the joint users, each of whom had to devote so many days each month toward repair. The water was also distributed among its users by set rules and at stated times, each district with its branch ditch getting so many hours' flow of the stream. The land thus cultivated was always in the vicinity of the streams, as no long ancient conduits were built, and was styled "taro" land, in contrast to "kula" or dry land, which carried no water rights.

The native Hawaiians have protected, with the greatest zeal, their water rights to taro land, which the gradual growth and expansion of sugar-plantation interests have tended to absorb.



MOUNTAIN SCENERY ON LINE OF OLOKELE IRRIGATION DITCH, MAKAWELI, KOUAI, HAWAIIAN ISLANDS.

Modern Irrigation.

The present water-supply of the islands is derived from two sources: (1) By pumping ground-water or artesian waters from wells and sumps, excavated near the seashore. The pumps are driven either with coal or oil as fuel, or by electricity generated from water-power. (2) By gravity from the natural flowing streams, the impounding of the flood waters of these streams, and by the interception of ground-water by tunneling.

One of the most striking facts which the continental engineer has to experience is the extraordinary productiveness of some of the island drainage areas, and this destroys at once many preconceived theories as to what run-offs should be. The Waihee drainage area, on Maui, about 4 sq. mi. in extent, yields a daily mean flow of 17,000,000 gals., while the Olokele drainage area on Kauai Island, of about 8 sq. mi., yields a mean flow of 40,000,000 gals. in 24 hours. Each of these areas is peculiarly and favorably situated for precipitation, with steep brush-covered slopes, and with almost daily rainfalls.

Nearly all the Hawaiian streams respond very quickly to rainfall, rising and falling quite rapidly, while those with a good dense brush-covered area hold a volume in the streams almost constantly above a certain minimum.

Artesian Supplies.

The artesian supply of the Island of Oahu is the most peculiar and the most generous found in any country of such a limited area, the island being only about 12 miles wide, north and south, by 35 miles long, with mountain ranges near its north coast 3,000 ft. high. It yields daily from the wells and sumps 250,000,000 to 300,000,000 gals. without diminution of the supply, the source of which is in porous strata found at a depth of from 400 to 800 ft. below the sea level. The static level of the water in the wells penetrating this formation varies from an elevation of 40 ft. above the sea at Honolulu to 22 ft. at Ewa Plantation, 16 miles westward. Excessive pumping or prolonged droughts vary this level somewhat, but it is always restored quickly on the cessation of the affecting conditions.

The islands are all of porous stratified lava, formed in layers by successive emissions from the ancient central cones which now form the summits of the islands. The water-supply in the artesian strata near the sea is sustained by

*Union Trust Building, San Francisco, Cal.

mountain precipitation, and the intimate connection between the mountains and the wells is proven by the sudden discoloration of the water in the latter some hours after heavy rainfalls in the mountains.

The artesian condition of the Oahu strata is caused by a tight coral and clay cushion which rests on the foreshore and prevents the water from escaping to the sea. In none of the other islands, owing to the absence of this necessary formation, is artesian water found, the pumps being fed from sumps excavated 5 to 8 ft. below the sea level, in all of which the water level fluctuates from 1 to 2 ft., corresponding with the tidal changes, which vary in this tropical region from 2 to 4 ft. between low and high waters. The depth to which it is safe to lower the static water level in Oahu wells by pumping has been tested in each plantation. The rapid increase in salt per gallon by excessive pumping, and the consequent lowering of the water level, forbids extreme practice in this respect. In normal condition, the Oahu artesian waters carry from 8 to 20 gr. per gal. of salt, while water with salt as great as 60 gr. per gal. will irrigate sugar cane successfully. The pumping stations are usually fed by a series of 12-in. wells, spaced 50 ft. apart and connected by a larger pipe with the suction ends of the pumps placed at as low a level as practicable. One million gallons have been pumped out of each well thus spaced, and 10 wells have been found sufficient for a 10,000,000-gal. pumping engine, which is the general size of unit adopted.

The water is usually pumped through a 24 to 30-in. discharge pipe, varying with the size of the pump and the head. Most of the water is delivered below an elevation of 300 ft., though in a few instances lifts as high as 450 ft. have been pumped against. The uncertain and fluctuating prices of sugar, the cost of fuel and other expenses practically preclude all profitable pumping above 400 ft. The work of pumping 10,000,000 gals. daily to 300 ft. elevation with the ordinary pumps in service will consume 15 tons of coal, which, at $8 per ton, would mean $120 per day for fuel expense alone. The cost of labor, lubricants, depreciation, etc., has to be added to get the total cost. Owing to the extreme fertility of the soil as many as 8 and 12 tons of sugar per acre are raised, which yields a return of about 10 to 12% per annum on the investment. Five plantations on the Island of Oahu, namely Kahuku, Waialua, Waianae, Ewa, Oahu and Honolulu, have a pump capacity of 287,000,000 gals. daily, with a water horse-power of 11,847, and draw water from 195 wells. Waianae furnishes the novel feature of using the fall in some gravity water, about 2,000,000 gals. daily, found in its high levels (500 to 1,400 ft.) to develop power, after which the water is again used for irrigating the lands lower down, while the power is transmitted to electrically-driven pumps near the sea level to lift ground-water from wells to the 150-ft. level.

Maui comes next with a pump capacity of 140,000,000 gals. daily, or 6,945 HP., the water being drawn from sumps. Kauai has 55,000,000 gals. daily pump capacity, with 2,033 HP., drawing principally from sumps. Hawaii, which is the largest of the islands, has only one pump, of 7,000,000 gals. capacity, or 412 HP., pumping from a shaft and sump.

The steep slopes, porous soil and high elevations of the plantations have prohibited irrigation on the Island of Hawaii, which, geologically, is the most recently formed of all the islands. No flowing surface stream exists for a distance of 200 miles on the coast, from Kohala southerly around to Hilo. The soil is of such a porous nature that it passes the rainfall through like cinders, and allows no surface accumulations of water. The volcanoes Mauna Loa and Kilauea are intermittently active, and emit two distinct varieties of lava; "pahoehoe," which is heavy and compact, having sometimes a smooth, glassy and undulating surface, and "A.A.," which is of much less specific gravity than the former, often floating on its surface during flows and breaking up into all kinds of disintegrating masses on cooling.

Experience with the direct-acting, slow-moving pump of the Worthington type has not been encouraging. All new pumps now installed are of the high-speed, fly-wheel type, which consume much less coal. Where all fuel has to be imported expensively, the greatest economy for this object has to be obtained. The pumps are nearly all installed in concrete-lined pits, 36 to 50 ft. sq., excavated to the water level, while the boiler plants are on the ground surface above. In three instances, at Oahu, Kihei and Kohala, the experiment of sinking shafts from the ground surface 200 to 300 ft. down to the water level, and excavating pump compartments at this level, has been tried. The difficulties of ventilation and the expense of the shaft chamber have more than balanced, in each instance, the saving of cost of placing a longer delivery pipe on the surface, with its added friction loss, the elimination of which were the principal inducements for installing this system. The ground-water in such a shaft, two miles from the sea, has also been found as brackish as water found in wells 100 yds. from the beach.

FIG. 1. WATER WASTING FROM TUNNEL IN MOUNTAIN. MAKAWELI, KOUAI, HAWAIIAN ISLANDS.

Outside of Oahu all pumping has to be prosecuted very cautiously, as too great a lowering of the sump level will increase the quantity of salt in the water, running it up to 100 or 200 grs. per gal., which renders it unfit for irrigation purposes, as it incrusts the soil with salt and damages the cane plants. Owing to the great porosity of the rock formation and the heavier specific gravity of the sea water, the tendency of the latter is to force itself inland where any suction is created by excessive pumping and consequent lowering of ground water. Herewith is a table of pump statistics by plantations.

Gravity Supplies.

All available streams are now tapped by ditches on Maui and Kauai. The first was built on the windward side of Maui in 1878 by Mr. H. P. Baldwin and Mr. S. T. Alexander. The next was built in the same section by Mr. Spreckels in 1879-80, under the supervision of Mr. H. Schussler, of San Francisco, as engineer. It is about 30 miles long, of 50,000,000 gals. daily capacity, and delivers the water at an elevation of 250 ft., and is known as the Haiku ditch. This ditch was intercepted by a new work called the Lowry ditch, in 1900, which delivers the water at an elevation of 450 ft. The writer has just finished a new aqueduct, known as the Koolau ditch, which taps all the Nahiku rain belt at an elevation of 1,250 ft., and discharges into the older and lower ditches. It is 10 miles long, 7½ miles being in tunnel and 2½ miles in open ditch and flume. The tunnels are all in solid rock, 8 ft. wide and 7 ft. high, with a daily capacity of 85,000,000 gals. Owing to the extreme porosity of the lava rock, 4½ miles of concrete lining, 6 ins. thick, is used in the tunnels to prevent seepage. The work was all done by Japanese with hand-drills (see Fig. 3). Ore cars were used in moving the excavated materials. The finished cost of the tunnel was about $7 per lin. ft.

The Japanese make excellent miners and rock men. Owing to their small size, it was practicable to work four in a face, and by working three eight-hour shifts, the whole work was completed in 18 months from the date of commencement, April, 1903. There are 38 tunnels, each averaging 1,000 ft. long, the shortest being 300 ft. and the longest 2,710 ft. The country was so steep and precipitous that little ditching could be used, and it was necessary to make 4½ miles of wagon road and 18 miles of stone-paved pack trails to facilitate, during construction, the transportation of supplies. About 7,000 bbls. of cement and 240,000 lbs. of giant powder were used. In all, ten mountain streams are intercepted, which are admitted into the main aqueduct through screens of grizzly bars, spaced ¾-in. apart.

The Honokahau ditch, with 30,000,000 gals. daily capacity, has just been finished on West Maui. It is 13½ miles long, on a grade of 5 ft. per mile, and has 2,000 ft. of 36-in. siphon pipes and 3½ miles of tunneling, and has cost $185,000. It delivers water at an elevation of 700 ft. to Lahaina Plantation. Mr. J. S. Molony, M. Inst. C. E., was engineer in charge.

All streams on the Island of Maui, including the Waihee stream at Wailuku, are now tapped by the ditches previously referred to.

The Hanapepe ditch, Makaweli, Kauai, was built by Mr. Baldwin in 1890 to tap the stream of that name. It has 7,040 ft. of 40-in. riveted steel siphon pipe, 1,013 ft. of tunnels, 14,618 ft. of flume, 5 ft. wide by 40 ins. deep, and 10 miles of ditching on a general grade of 6 ft. per mile, and carries 35,000,000 gals. daily. The use of wooden flumes in tropical countries is not advisable, as repairs have to be made frequently, owing to the rapid decay of the wood. This ditch delivers water on the plantation at 450 ft. elevation, and a new one, just built and completed under the writer's supervision, known as the Olokele ditch, delivers water at an altitude of 1,075 ft., and has a daily capacity of more than 60,000,000 gals. It involves 8 miles of 7 × 7-ft. tunnels, 5 miles of ditching, and it has cost completed about $360,000. At one point a drop

of 228 ft. was obtained, which it is proposed to utilize for electric power purposes in operating the plantation mill and railway. Makaweli Plantation, owning both those ditches, has now the best gravity supply on the islands, with a daily minimum from its two sources, of 65,000,000 gals. It is proposed, later on, to store the freshet waters in reservoirs, and to use them as balancing mediums to restore the supply when the streams run low. Owing to the steep land slopes, 6 to 15 degrees, it is very difficult to select economic or favorable reservoir sites, except in the center or back of old volcanic cones.

Many streams have been diverted and reservoirs made during the last five years on the Wailuku and Pioneer plantations on Maui, the Oahu and Waialua plantations on Oahu, and the Koloa, Makee and McBryde plantations on Kauai; but, for the reasons before stated, practically no stream diversion for irrigation has been made on the largest island, Hawaii, except the Kohala ditch, completed last year by the writer.

KOHALA DITCH.—Surveys for the Kohala ditch were commenced in January, 1905, under the writer's direction. Construction work was begun the first week in April and water was flowing for 14 miles on June 11, 1906. This ditch is located on the north slope of the Island of Hawaii, in the Kohala district, and conveys the water from a highly precipitous mountain country to the level cane fields in Kohala. The work was conducted under the greatest difficulties, as almost continuous rains were experienced from April to July, during all of which time trails had to be made and materials transported and shelter and buildings made for housing 600 Japanese laborers. Those men seemed to like this class of work and made a success of breaking rock where other nationalities were a failure. As their wages average only $1 per day for the ordinary classes of lava rock encountered, hand drilling with Japanese is more economical than the use of either air or electric drills. An experiment was made in one case with a gasoline drill, which proved an absolute failure and had to be consigned to the scrap heap.

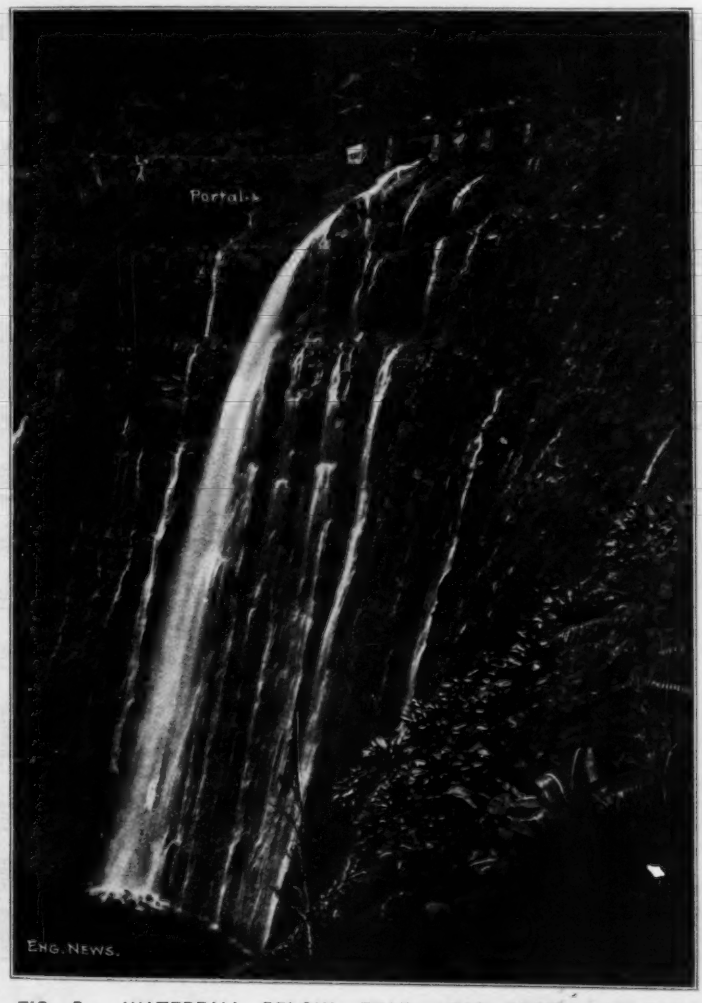


FIG. 2. WATERFALL BELOW TRAIL NEAR PORTAL OF TUNNELS 12 AND 13, KOOLAU DITCH, KEANOE, MAUI, HAWAIIAN ISLANDS.

In the 14 miles there were:

45 tunnels, aggregating	46,000 ft.
20 flumes, aggregating	2,000 ft.
Ditching	23,000 ft.
Total ..... 14 miles or	71,000 ft.

The longest tunnel was 2,500 ft., and was cut through in 10 months, being completed on March 24, 1906.

TUNNELS.—The tunnels in this work were altered slightly in section from the ones in Olokele and Koolau, as the sides were tapered. The bottom width was 6½ ft.; 5 ft. up the width was 8 ft. The crown of the arch was 7 ft. above the floor. The object of this modification was to make a better bedding for the concrete lining than that afforded by vertical sides.

FLUMES.—The flumes were of the most substantial kind, thoroughly calked and tarred, being 7 ft. wide by 5 ft. deep. They were supported by three 10 × 12-in. posts on 10 × 12-in. sills, resting on masonry piers, 16 ft. c. to c., set in cement mortar. The top of the masonry was well above the flood line, so as to lengthen the life of the timber.

DITCHES.—The ditches are 12 ft. wide on the top, 7½ ft. wide on the bottom and 4½ ft. deep. They were lined with ¾-in. of 1:2 cement plaster, and were capped on each side by 6 × 6-in. concrete rims.

GRADES.—The fall in tunnels and flumes is 1 ft. in 833 ft., and in the ditch of Hawaii is 1 ft. in 1,000 ft. The elevation of the bottom of intake above sea level at the first large stream (Honokane) is 1,035 ft., and at the terminus in the plantation fields, 956 ft.

MEASURING WEIRS.—There are two main measuring weirs, consisting of three panels each, with 5-ft. openings, capable of measuring up to 70,000,000 gals. daily, the capacity of the ditch when full.

CEMENT LINING.—In the 14-mile section about 10,000 bbls. of cement, 2,500 cu. yds. of crushed rock and 6,200 cu. yds. of sand were used in lining the sides and bottoms of the tunnels where necessary to obviate seepage in porous strata and in arching to prevent caving in weak formations. The beach sand was rather poor in quality, and the cost of packing, hauling and handling to the point where used on the ditch made it more expensive than crushing the materials on the site from blue rock with the rock crusher which was installed for this purpose. The sand, cement and rock were trammed through the tunnels in cars pulled by mules, which was found to be a very economical means of distribution. The hauling and distribution of materials was done at night and the mixing and placing by the day shifts. Six inches of concrete or stone masonry was placed 5 ft. high in the sides, and an arched concrete roof, with weep holes, was placed where the ground was of a caving nature. The cement purchased was A1 imported Alsen and Germania brands, averaging $2.60 per bbl. in Honolulu. The steamer and other transportation rates from Honolulu averaged $1.30 per bbl. more. The following gives the quantity of cement work done on this job:

Stone masonry and cement, 5 ft. high sides	22,425 ft. lined
Concrete, 5 ft. high	9,145 ft. lined
Cement plaster, ¾-in. thick on ditch	19,035 ft. lined
Arched concrete roofing	3,923 ft. lined
Bottom plaster to floor of tunnels	20,000 ft. lined
Masonry and flume piers	1,000 cu. yds.

About 250 draft and pack mules were used on this work, the native Hawaiian mule being very handy and durable for packing purposes.

About half the work was inaccessible to wagon roads, and narrow pack trails about 5 ft. wide were cut out of the sides of the mountain precipices and used for packing materials. The cost of this work was about $402,000. The price paid by the plantations for the water, which is measured to them over weirs from the ditch, is $2,500 per 365,000,000 gals.

An hospital and medical department was provided for the men, who were assessed 50 cts. per month apiece for this object. The Japanese are indifferent to weather conditions, rain and exposure seeming to keep them in a healthy condition, while white men, similarly exposed, would be disabled by rheumatism and other ailments. While prone to listen to the advice of agitators, compared with similar bodies of white men working under similar conditions, their conduct may be considered conservative.

HOUSING ARRANGEMENT.—All the men were housed under corrugated iron roofs, framed by light scantlings, such as 2 × 3 ins., which could be easily packed. The side walls were made of 8-oz. duck, tacked to the scantlings. The floors were 1 × 12-in., nearly always 2 ft. above the ground, and higher if practicable, so as to provide a place for drying the men's clothes in wet weather. Such accommodation was found much better and healthier than tents, which quickly rotted under the heavy rains.

The type of track used by me in all this work consisted of band rails 1½ ins. wide and 3/16-in. thick, 16 ft. long, with holes reamed out for track spikes about 2 ft. c. to c. These were spiked to longitudinal 2 × 3-in. sleepers, notched into and clamped with hardwood wedges to the ties about 4 ft. c. to c. Those ties were procured from the native woods of the country encountered along the rights of way. The track gage in all cases was 18 ins. The rock cars used for conveying materials were 3 ft. wide by 4½ ft. long, and were made on the ground and mounted on 12-in. wheels on 2-in. axles, the whole car being tipped off the track and one sideboard lifted when emptying. The miners liked those cars better and found them more efficient than the ordinary automatic iron ore cars, which cost three times as much. Below is a table showing the number of caps, fuses, powder and candles used per foot in the construction of the Koolau ditch tunnels in the year 1903:

5 lbs. of powder, at 15 cts.	$0.75
8.9 caps	.067
16.9 ft. of fuse	.084
0.6 lb. of candles	.072
Per 2 cu. yds. of excavation	$0.973

It was generally found more advisable to do all work on a contract basis, paying so much per running foot, increasing the price on a fixed rate for each hundred feet that the tunnel extended in length, compelling the miners to pay for all the ammunition and candles used each month. In this way they were more economical in using the materials than if such were furnished them free. Free materials were tried in my first work at Olokele and found to be expensive, as the men wasted powder in a reckless manner, and it was impossible to curb their extravagance.*

Associated with me in this work for the past four years have been Mr. W. E. Sauer, C. E.; Mr. J. Jorgensen, C. E.; Mr. E. F. Rogers, a California miner; Mr. A. Glennan, Mr. P. Bluett and Mr. H. Cooper.

GROUND-WATER.—The most novel development in water-supply has been the discovery of

*The average cost of excavating the tunnels, including supplies, track and labor, was $4.50 per ft.

STATISTICS OF IRRIGATION PUMPING PLANTS, HAWAIIAN ISLANDS.

Island.	Agents for plantation.	Plantation.	Manufacturers of pumping engines.	Type of water end.	Diam. plungers, ins.	Capacity, gals., 24 hrs.	Total lift, ft.	Water, HP.	Diam. discharge pipe, ins.	Length of discharge pipe, ins.	Type of motor end.	Size steam cylinders, ins. H. P.	I. P.	L. P.	stroke.	Steam pressure, lbs.	Piston speed, ft. per min.	Tons coal 24 hrs.	Coal used.	Static level of water, ft.	Number of wells.
Oahu	Alexander & Baldwin	Kahuku	H. R. Worthington	Four cylinder duplex plunger & ring.	19¼	5,000,000	210	187			Six cylinder triple expansion.	12	20	34	24	140	134	3½	Roslyn	10	4
"	" "	"	"		21	6,000,000	150	154	24	2,560											
						12,000,000	50	105													
"	" "	"	"	Fraser & Chalmers	Duplex outside packed.	13 9/16	8,000,000	347	486	24	3,980	Four cylinder triple expan.	15¾	26¾	28¾	36	175	420	10	"	4	8
"	" "	"	"	Blake Co.	Duplex plunger & ring.	36	14,000,000	55	135	30	800	Six cylinder triple expansion.	12	22	38	36	95	84	3	"	6	Open sump
"	" "	"	"		Centrifugal.		3,000,000	33	17			Cummer high pressure.	16	..	..	24	70	...	2½	"	2	2
"	Castle & Cooke	Apokaa	Fraser & Chalmers	Single packed plunger.	10	2,500,000	65	28	12	2,000	Single Corliss.	8	..	..	24	100	284	21	Bituminous co-operative	..	1
"	" "	Ewa	" "	Duplex packed plunger.	15⅞	11,000,000	51	114	30	200	Comp. Corliss.	12	..	18	36	140	420	5	" "	..	8
"	" "	"	Blake Co.	Duplex plunger & ring.	12	3,000,000	80	42	12	300	Comp. slide & poppet valves.	11	..	19	24	90	190	2	" "	..	2
"	" "	"	"	" "	18	7,000,000	105	128	30	1,500	Comp. Corliss.	15	..	30	30	85	194	6.5	" "	..	8
"	" "	"	"	" "	20	9,000,000	105	166	30	3,000	" "	20	..	40	40	85	200	10	" "	..	8
"	" "	"	Fraser & Chalmers	Duplex packed plunger.	16	10,750,000	105	197	30	1,110	" "	20	..	32	36	120	420	8	" "	..	6
"	" "	"	" "	" "	10⅝	10,125,000	200	354	30	4,730	" "	24	..	40	42	120	800	11.5	" "	..	6
"	" "	"	" "	Triple packed plunger.	11⅝	11,740,000	160	328	30	1,500	Triple exp'ns'n Corliss.	14⅝	24	36	42	180	504	10	" "	..	6
"	H. Hackfeld & Co.	Oahu	" "	Duplex packed plunger.	11	5,650,000	450	445	30	1,500		..	..	..	..	160	434	11.5			3
"	" "	"	" "	Triple packed plunger.	11⅞	10,700,000	370	695	30	5,000	Triple exp'ns'n Corliss.	19	33	50	42	175	460	14.1			7
"	" "	"	" "	Duplex packed plunger.	12	6,600,000	550	638	24	9,225		..	..	..	..	165	420	19			7
"	" "	"	" "	Triple packed plunger.	11⅞	10,700,000	344	645	30	6,000	Triple exp'ns'n Corliss.	19	33	50	42	180	460	15			8
"	" "	"	" "	Duplex packed plunger.	15½	10,300,000	556	1,000	24	10,000	Four cylinder triple Corliss.	27	46	50 50	42	165	385	24			10
"	" "	"	" "	" "	14	8,660,000	146	222	24	2,500	Comp. Corliss.	20	..	32	36	125	390	65			5
Maui	" "	Pioneer	Braunschueiger	" "	11	5,000,000	465	408	14	.....	Cross compound poppet valves.	23	..	38	42	180	370	10	Bituminous	Sea	6
"	" "	"	" "	" "	11	5,000,000	465	408	14	.....	" "	23	..	38	42	180	370	10	"	"	6
"	" "	"	Worthington	Duplex plunger & ring.	15	3,000,000	115	60	14	.....	Six cylinder triple direct act.	8	12	20	15	125	120	4	"	"	2
"	" "	"	"	" "	15	3,000,000	115	60	14	.....	" "	8	12	20	15	125	120	4	"	"	2
"	" "	"	"	Duplex packed plunger.	19	5,000,000	540	474	18	.....	" "	21	33	60	36	160	125	10	"	"	5
"	" "	"	"	Duplex plunger & ring.	20	5,750,000	275	277	18	.....	" "	16	25	46	24	160	130	8	"	"	5
"	" "	"	"	" "	24	8,750,000	100	452	24	.....	" "	12	20	34	24	160	134	6.5	"	"	8
"	" "	"	"	" "	15½	3,500,000	460	281	16	.....	" "	16	25	46	24	160	130	7	"	Sea level	4
"	" "	"	"	" "	15	3,000,000	65	34	12	.....	" "	6	9	16	15	160	120	3.5	"	"	3
"	" "	"	"		18	4,500,000	420	330	17	.....		18	30	50	24	160	125	8	"	"	4
"	Alexander & Baldwin	Haiku	Fraser & Chalmers	Duplex packed plunger.	10⅝	5,500,000	440	425	20	4,500	Comp. Corliss.	24	..	40	36	125	454	12	New Castle and Departure Bay	Sea	6
"	" "	"	" "	" "	10⅛	4,000,000	256	180	18	550	" "	18	..	30	36	125	350	5½	" "	"	4
"	" "	Kihei	H. R. Worthington	Duplex plunger & ring.	20	6,000,000	320	336	20	11,500	Six cylinder triple direct act.	17	27	48	24	180	134	18			Open sump
"	" "	"	" "	" "	20	6,000,000	200	210	20	7,350	" "	16	25	46	24	180	134	18			"
"	" "	"	Risdon	Duplex packed plunger.	14⅞	7,000,000	450	551	28	4,400	Four cylinder cross compound Corliss.	24	40	43	43	160	290	35			"
"	" "	"	Fraser & Chalmers	" "	14 9/16	10,000,000	350	612	28	1,700	" "	19	36	36 36	36	160	420	35			"
"	" "	H. C. & S. Co.		Duplex plunger & ring.	14½	7,400,000	110	143	24	3,975	Cross compound poppet valve.	16	..	32	36	80	312	6.2	Nanaimo British Columbia	Sea level	"
"	" "	"		Centrifugal 40" runner.	..	2,250,000	65	26	18	2,100	Single cylinder high pressure.	16	..	..	36	80	...	4.8	" "	"	"
"	" "	"		Duplex plunger & ring.	14½	7,750,000	45	130	24	1,850	Cross compound side valve.	16	..	32	36	85	324	5.8	" "	"	"
"	" "	"	Fraser & Chalmers	Duplex packed plunger.	14¾	8,300,000	209	305	28	4,200	Cross compound Corliss.	24	..	32	42	125	372	8.6	" "	"	"
"	" "	"	" "	Triple packed plunger.	11⅞	8,800,000	184	283	30	7,200	Triple expansion Corliss.	19	33	50	42	180	375	6.7			
"	" "	"	" "	" "	..	8,800,000	314	483	30	10,450	" "	19	33	50	42	180	375	7.5	" "	"	"
"	" "	Paia	H. R. Worthington	Centrifugal.	..	1,500,000	35	10	10	.....	High pressure engine.					90	294	3	Ladysmith	"	"
"	" "	"	Fraser & Chalmers	Duplex packed plunger.	..	.....	40	...	8	1,200	Comp. Corliss.	9		18		90	180	3	"	"	"

"	334	15	5,250	"	"	18	"	30	"	135	300	14½	"	"	"	"	"	"	"	"	"	"	"	"	"
"	433	24	10,580	"	"	24	"	40	"	135	121	14⅝													
Kauai	52	20	.....	Cross compound Corliss.		10	"	20	"	150	250	2.5													
"	...	24	.....	"	"	12	"	20	24	120	300	3	Wilhelmina												
"	41	15	4,750	Compound Hamilton Corliss.		12	"	18	"	120	300	2.25	New Castle Departure Bay			20									
"	75	30	1,700	"	"	12	"	24	36	120	288	26	"	"		20		7							
"	...	...	.....	"	"	12	"	24	36	120	252	3.75	"	"		"		12							
"	98	24	2,400																						
"	605	30	1,200	"	"	25	43	66	42	165	290	18	"	"		12		18							
"	262	24	1,000	Four triple direct acting.	cylinder	15	33	57½	36	150	112	14	"	"		10		10							
"	52	8	400	Compound direct acting.		8	"	18	12	100	180	1	New Castle			..		..							
"	412	24	6,000	Four triple.	cylinder	15½	25½	28⅝ 28⅝	36	175	400	7	"	"		5		5							
"	...	...	.....	Six cylinder triple direct act.		6	9	16	15	115	115	Trash is used				6		1							
"	29.4	6	3,000																						
"	...	...	.....	"	"	24	"	20	24	120	300	3	"	"		20		Open ditch							
"	41	15	4,750	"	"	12	"	18	"	120	300	2.25	"	"		18		18							
"	75	30	1,700	"	"	12	"	24	36	120	288	26	"	"		20		7							
"	...	...	.....	"	"	12	"	24	36	120	252	3.75	"	"		"		12							
"	98	24	2,400																						
"	605	30	1,200	"	"	25	43	66	42	165	290	18	"	"		12		18							
"	262	24	1,000	Four triple direct acting.	cylinder	15	33	57½	36	150	112	14	"	"		10		10							
"	52	8	400	Compound direct acting.		8	"	18	12	100	180	1	New Castle			..		..							
"	412	24	6,000	Four triple.	cylinder	15½	25½	28⅝ 28⅝	36	175	400	7	"	"		5		5							
"	...	...	.....	Six cylinder triple direct act.		6	9	16	15	115	115	Trash is used				6		1							
"	29.4	6	3,000																						
"	...	...	.....	"	"	24	"	20	24	120	300	3	"	"		20		Open ditch							
"	41	15	4,750	Compound Hamilton Corliss.

The Preparation and Use of Stone and Gravel Ballast.*

The statement is frequently made, especially by users of crushed rock ballast, that to quarry and deliver stone ballast on track increases its first cost over other materials, but its economic value is much greater, owing to better track secured and longer life of ties, with less frequent necessity for relining and resurfacing.

Users of large quantities of gravel ballast, however, do not admit all of these claims, particularly that of better riding track. It is said that when track is to be raised only a very small amount, it is difficult to do this on stone ballast and to properly tamp the tie to an even and uniform bearing. For this reason it is claimed that gravel makes a more smooth riding track. Likewise, it is more difficult and costs more to renew ties in stone, owing to the handling of the material.

The kind of ballast to be used is most frequently determined by local conditions. But when several kinds are to be had it is very difficult to determine in exact figures under what conditions of weight of rolling stock and motive power and frequency of traffic it becomes most economical to begin the use of broken stone for ballast.

Passenger traffic might demand its use, more from the point of view of the comfort of passengers and its appearance than from actual pressures to be sustained. It would not be economical to ballast with stone a single track branch or feeder having a light freight business, where maintenance is not given the attention that is necessary on main lines. It is generally claimed that a saving will accrue from the use of stone of the proper qualities for ballast wherever it becomes necessary to support the heavy pressure and impact of modern engines, and this would be particularly true of roads carrying a large coal traffic in large capacity cars.†

In all probability, it will be found in future experience that the size of ballast will vary with the class of stone used. Smaller stone is desirable in securing smoother riding track, and for raising tracks an amount less than the size of the larger stones. In the harder rock, such as trap, smaller stone may be used, as it does not pulverize so readily from traffic and tamping. In limestone, the smaller sizes may be eliminated, as the larger sizes soon go to pieces, and, when the stone has high cementing values, this pulverizing constitutes one of its greatest disadvantages, and causes mud-pumping of the track.

Fine ballast is capable of producing smooth riding track with less labor, when it is first put in, yet does not hold track in as good line and surface under heavy traffic as ballast of larger size. Large size stone, with sharp fracture, holds the track in better line and surface under heavy traffic, but costs a little more for first tamping.

The advantages of gravel ballast are lower first cost than crushed rock, lower cost of tie renewals and greater ease with which a light raise, to give a fine surface, may be made. The disadvantages are dust, inability to hold line and surface, churning when wet and allowing growth of weeds. These disadvantages, however, exist in greatly varying degrees and in carefully prepared gravel ballast disappear altogether. While it is true that some of the users of crushed rock maintain that it is superior to the best gravel, the evidence is not sufficient to warrant an unqualified statement to that effect. Under extremely heavy traffic the indications are that crushed rock will stand better than the best gravel, but some of the best riding track in the country, with fast passenger service over it, and with reasonable maintenance expense, is put up on gravel.

Some tests of pit gravel on the Cleveland, Cincinnati, Chicago & St. Louis Ry. have thrown light on the question of effect of sand and dust in gravel ballast, and the result of the tests is given in the accompanying table. These tests were made on small sieves by hand and must therefore be regarded as laboratory tests, rather than working tests under everyday conditions:

PERCENTAGE OF GRAVEL, SAND AND DUST IN BALLAST, BY VOLUME.
(Compared to Original Volume.)

Gravel. P. ct.	Sand. P. ct.	Dust. P. ct.	Remarks.
81.6	27.0	1.3	Very good.
61.3	50.9	2.8	Fair.
68.0	44.1	2.9	Good.
86.0	12.5	6.5	Poor—cementing nature.
56.0	62.0	2.0	Too recent to determine.
59.6	55.4	3.6	Good but dusty and excess of sand increases track labor.
58.7	49.1	12.9	Very poor. Only fit for sub-ballast.

Gravel having 3% or less of dust has been found to drain very freely, while gravel having an excess of 3% dust is found to hold water to such an extent as to interfere with its thorough efficiency as ballast. Gravel containing 2% dust will make a fairly dustless roadbed, but after being disturbed by track work it will cause considerable dirt until washed by a heavy rain.

It has been found necessary to have about 30% sand to partially fill the voids in the gravel. Lack of at least 20% of sand permits the pebbles to shift under the load and an excess of 50% prevents the ballast from becoming firm. In dry weather the action known as "pumping" or "blowing" takes place.

The committee recommends therefore, as good practice, the following proportions:

For Class A roads: 10 parts gravel and 3 parts sand. Where bank gravel contains more than 2% dust or 40% sand it should be screened or washed.

For Class B roads: 10 parts gravel and 6 parts sand. Where bank gravel contains more than 3% dust or 60% sand it should be screened or washed.

For Class C roads: 10 parts gravel and 10 parts sand. Any bank gravel which does not contain an excess of 6% dust may be economically used.

Stone Ballast Quarry Plant; D., L. & W. Ry.*

Early in 1905 our company acquired by purchase near Boonton, N. J., a granite quarry and crusher plant. The material obtained from this crusher plant is a very good quality of New Jersey granite, weighing 2,795 lbs. per cu. yd. of crushed stone.

The quarry was well opened up when we acquired it from the contractor. The face has a depth of from 20 to 60 ft. and a length of about 2,200 ft. The stripping on top of the quarry will average about 2½ ft. The crusher machinery consists of one No. 8 and one No. 6 crusher, with a large bucket conveyor for conveying the broken stone from the crusher to the screens. There is one 48-in. screen, consisting of three sections, each 4 ft. in length, with holes from ½-in. to 2½ ins. diameter and a dust jacket for separating the materials. Materials which pass through the ½-in. ring are not used for track ballast.

The ballast product is conveyed on a belt conveyor and deposited in a system of bins; the finer material and dust pass directly over the dust jacket into the dust bin. The percentage of fine materials (dust and ¼-in. stuff) runs from 12 to 14% of the total output.

The grades of tracks at the crusher plant are so arranged as to handle the cars after being placed by gravity. There is a powder magazine for about ten tons of powder and explosives. There is also a water system for the boilers and a sprinkling plant to keep down the dust. The maximum grade of the track connecting our main line with the quarry is 3% ascending to the quarry, and in handling our ballast we have been utilizing a locomotive which will handle 14 empty ballast cars up this grade.

The larger part of the stone is handled from the quarry to the crusher plant by means of a derrick system, the face of the quarry being located quite close to the crusher plant. We have in use six large derricks with 90-ft. masts, which, with six hoisting engines operated in connection with the derrick system, handle the stone in large stone boxes. The stone is quarried from the top of the face by a stepping system. To pass into the No. 6 crusher the stone has to be broken up in sizes from 16 ins. to 20 ins. The breaking of the material is done with a system of block hole drills, placing holes from 6 ins. to 12 ins. apart, depending upon the size of the stone to be broken. We use from three to six block hole drills per day in breaking up the larger stone, and some of the smaller stones are sledged instead of being block holed.

In addition to the derrick system we also have a car system, by means of which cars loaded with stone from the quarry are dropped by gravity to the crusher. These cars have from 12 to 16 yds. capacity, and are dumped by one of the derricks. The bottom of the cars is of wood and metal, with a chain attached, and the false bottom of the car is picked up on one end by the derrick, and the stone dumped by this means without manual handling. After the cars have been dumped at the crusher they are returned to the quarry by a haulage system, operated by a hoisting engine. The stripping from the top of the quarry is disposed of by piling it back from the face of the quarry.

In operating the quarry and crusher we have employed an average of 125 men, including rock men, drill men, engineers, mechanical men and laborers required at the quarry and crusher. We employ two blacksmiths for handling the drill work and a pipefitter for taking care of the steam-pipe system and steam drills. One mechanical foreman with the necessary help has charge of the crushing plant and one general foreman has charge of the quarry. One engineman handles the engine in the crusher plant and one fireman does the firing. We also utilize a 150-HP. boiler for generating steam for the drills, and we have two 150-HP. boilers for furnishing the balance of power for the derricks and at the crushers.†

In handling the ballast on a 4½-mile section we had an average of 31 laborers at 14 cts. per hour per day of 10 hours and one foreman at $75 per month. In addition to the regular ballast gang we had eight [illegible] on the 4½-mile section that were employed [illegible] out, changing ties, placing drain tile [illegible] changes in alinement and easement curves [illegible] of ballast used on the 4½-mile section [illegible] was 28,458 yds., or an average of 6,324 [illegible] of double track. The average distance which [illegible] was hauled from the crusher to the [illegible] was 13 miles.

We used in this work 24 ballast cars, [illegible] the cost of transportation the cars were placed [illegible] of $600 each. Our records show a cost [illegible] yd., covering transportation charges, interest [illegible] last cars valued at $600 each at 5%, plus [illegible] on the net investment of the quarry and [illegible] The cost for quarrying, crushing and loading [illegible] crushing plant was 55 cts. per yd.; the [illegible] ballast under track, including lining, surfacing [illegible] ing, was 20½ cts. per yd., making a total [illegible] per yd. for the ballast in the track.

On the west end of our Buffalo Division [illegible] accurate record of the cost of 27,120 yds. of crushed limestone ballast put in on a stretch of double track during the season of 1906. For this work [illegible] the crushed stone delivered to us in our own ballast cars at an average cost of 60.17 cts. per cu. yd., and received an average of 222 cu. yds. per day, the quarry being located on our own lines. The average haul was 13.4 miles. The ringing used in preparing this ballast was from ¾-in. to 2½ ins. diameter and the stone weighed 2,410 lbs. per yd.

Pit Gravel.

STRIPPING.—In general, the best method for removing the waste material is to use a steam shovel, loading the material into cars and using it to widen embankments. When the depth of stripping is too shallow to permit the economical use of a steam shovel, teams with scrapers can be used to windrow the strippings, using a steam shovel to load the windrows. The cost of stripping a gravel pit with a steam shovel, using the material to widen embankments, when the haul does not exceed 20 miles, should not be more than 15 cts. per yd.

LOADING.—A heavy steam shovel with a dipper holding from 2½ to 3½ yds. makes a most efficient machine. Too great stress cannot be laid upon the advisability of having a shovel which has a large surplus of strength in all its parts, as economy in maintenance and in the operation, resulting from lessening the loss of time occasioned by stopping for repairs, is very great. Center dump cars, which deposit the material where it can be used without any casting with shovels, are most economical. The larger the capacity of the cars the better.

In connection with the center dump cars, ballast spreaders mounted under a flat car are a necessity. The practice of placing a tie or like obstacle in front of the wheels, allowing them to skid while the ballast is being pushed out of the way, is a bad practice, resulting in flat wheels, as well as loss of time in distribution of the ballast. Where only a small amount of ballast is to be handled, a device which will be mounted by the wheels and will itself slide on the rails can be used to good advantage. Where only a very small lift or none at all is to be made, a great saving in time of applying the ballast can be made by the use of a distributing plow, which plows out the ballast close to the tops of the ties.

In most cases it will be found best to organize a crew at the pit in charge of an able, experienced conductor, who will do all of the spotting of cars at the shovel, and, to a certain extent, to take charge of the movement of the other trains in the gravel service to the various distributing points.

COST.—It is impracticable to give any approximation of the cost of preparing the gravel pit for operation, as local conditions will govern this entirely. The cost of loading the gravel depends upon three conditions: (1) The size and efficiency of the shovel; (2) the depth of the bank from which gravel is being loaded; (3) the supply of cars maintained under the shovel dipper.

Where the bank is 10 ft. or more in depth the greatest efficiency of the shovel should be obtained. Not less than four pitmen should be used, that no time may be lost in shifting. Where the bank is less than 10 ft. in depth it will generally be found that the frequent shifting of the shovel will materially reduce the output of gravel. It is assumed that the train service is sufficient to keep the shovel supplied with cars in order to make use of its full efficiency.

With the above conditions obtaining, from 2,000 to 2,500 cu. yds. per day on an average can be handled, the cost of which will be approximately 2.5 cts. per yd., based on the following rates of pay:

1 Train engineman	$4.85
1 Train fireman	2.75
1 Conductor	4.85
2 Brakemen	7.00
1 Shovel engineman	4.80
1 Shovel fireman	2.70
1 Cranesman	3.45
1 Watchman	2.10
4 Pitmen	7.00
Fuel, oil and water for train and shovel	13.80
Total	$53.30

*From the report of the Committee on Ballasting, presented at the annual meeting of the American Railway Engineering and Maintenance-of-Way Association, held at Chicago, March 16 to 18, 1909.

†On the other hand, some coal roads prefer gravel, as the dirt from the cars soon chokes up clean stone ballast.—Ed.

*Information furnished to the committee by Mr. Lincoln Bush, while Chief Engineer of the Delaware, Lackawanna & Western Ry.

†A tabular statement in the report shows that for a period of 14 months the average cost was 55.51 cts. per cu. yd. (49.04 cts. for quarrying and 6.47 cts. for crushing).—Ed.

DISTRIBUTION.—The length of haul regulates entirely the question of the number of trains and the number of cars to a train which should be used. The one hard and fast rule should be that the best of motive power be furnished for this service. Generally speaking, for hauls less than 10 miles, one train in addition to the train at the pit is sufficient. Above 10 miles and under 30, two trains on the road will be sufficient. The only rule that can be stated is that, to get the most economical handling of ballast, to provide train service enough to keep the shovel well supplied with empties at all times. Where the haul is short the best practice is to put into one train only so many cars as can be handled readily by the engine which are assigned to that service. There is a decided loss on short-haul work where more cars are put into a train than can be dumped without difficulty by the engine.

When the haul is long all the cars should be given to a train that can be moved over the division, and enough set off on the siding nearest the distributing point to reduce the train to such size that the engine can readily handle it while dumping. This applies to center dump cars, where the movement of the train when being unloaded is very much harder than when on the road. In some cases it will be found economical to provide a train for the purpose of taking the loaded cars at the end of a long haul and unload them. It frequently happens that unforeseen delays occur during the unloading which will seriously cripple the through movement of the gravel trains, and on very long hauls the unloading train can be economically employed.

The cost of movement from the pit and distributing on the track depends wholly upon the length of the haul and congestion of traffic. The actual time consumed in distribution with center dump cars is immaterial, 30 mins. being sufficient time for the unloading of a train of from 400 to 500 cu. yds.

Washed or Screened Gravel.*

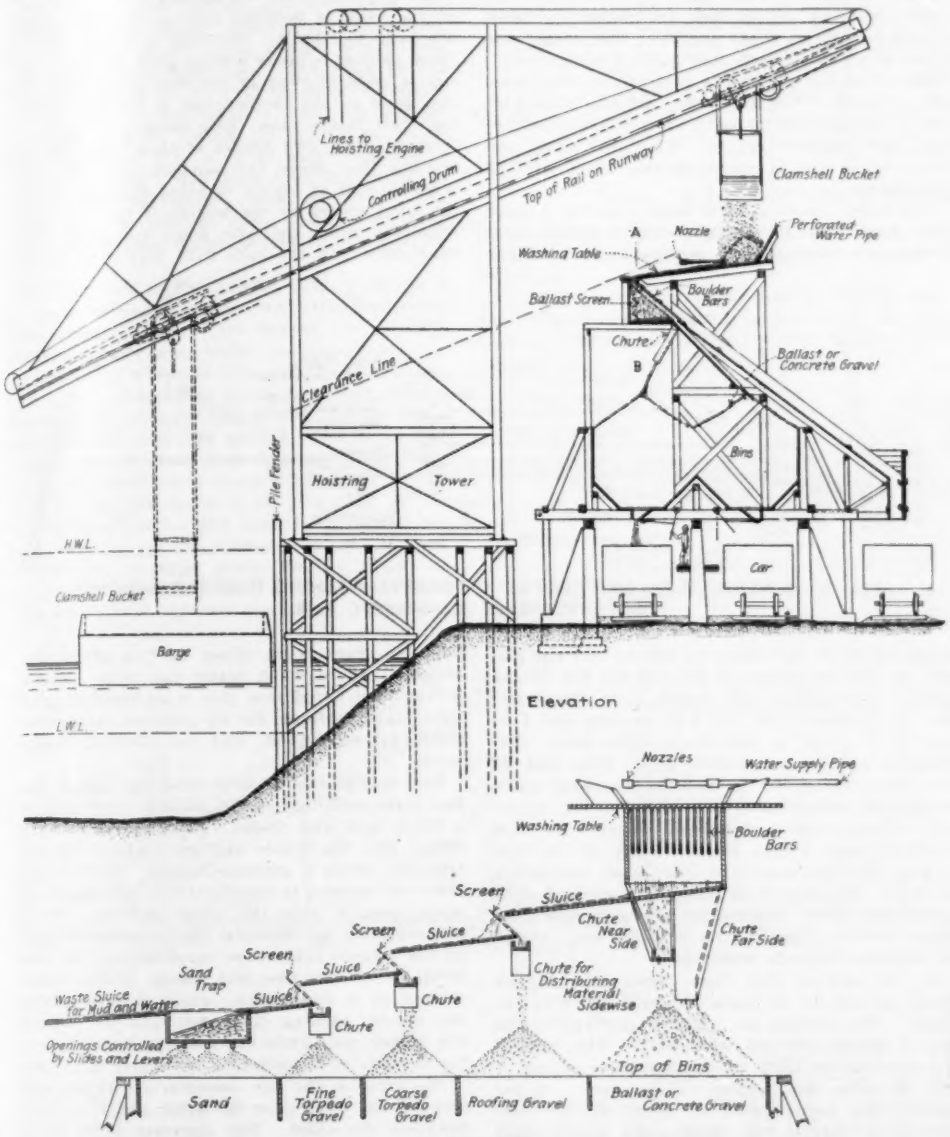
The essential features of a plant for this purpose are: (1) Positive separation of material into definite grades; (2) capacity to furnish gravel in quantities sufficient for economical use as ballast; (3) economical operation; (4) economical disposition of the refuse, both boulders and fine material.

In distributing ballast on track it is obviously necessary to produce the gravel in large enough quantities to permit the organization of the track forces on an economical basis. A plant which will produce gravel at a cost which would make it commercially profitable may be too small to produce ballast economically.

In the preparation of quantities of ballast there is necessarily produced a large amount of mud, sand and boulders or cobbles. To work successfully a plant must be so devised as to dispose of this rejected material. The stones should be run through a crusher and returned to the gravel for ballast, not only increasing the output, but improving the quality.

Plants for the washing or screening of gravel naturally divide into two types: (1) For handling material from submerged beds of gravel; (2) for handling material from upland gravel banks. The plant of the Union Sand & Material Co., South Memphis, Tenn., is a typical submerged gravel-bed washer, and the Lake Shore & Michigan Southern Ry. plant at Pleasant Lake is typical of the upland washer.

UNION SAND & MATERIAL CO.'S PLANT.—The equipment used is a fleet of one tug and six barges, with a capacity of between 250 and 300 cu. yds. each; one dredge, with two 15-in. centrifugal pumps, each equipped with a length of pipe varying from 30 ft. to 75 ft., depending upon the depth of the water. These suction pipes can be moved horizontally and raised and lowered by means of a derrick with boom extending out from the front of the dredge. The two centrifugal pumps can load a barge in about 70 mins., and, as the average distance traversed from the barge to the plant is about 1½ miles, the tug is kept busy transporting the loaded and empty barges. The dredge is about 130 ft. long, 30 ft. wide and heavy construction. The barges are 130 × 30 ft. over all. The accompanying cut shows a section of a typical plant.



SECTIONAL ELEVATION OF PLANT FOR EXCAVATING, WASHING AND SCREENING RIVER GRAVEL.
(Union Sand & Material Co., South Memphis, Tenn.)

Two boilers furnish steam to an engine with 12½ × 16-in. cylinders. This engine furnishes power for running the plant, as well as pumping water to wash the gravel, of which about 1,500 gals. per minute is used.

The plant proper is built up on a network of creosoted piles, driven down well into the bank of the river. These piles are all cut off at the same elevation and have cribbing placed on top of them, upon which the plant has been erected. On the river side of the plant, where the four-leg tower, which supports the overhead carrier, has been erected, there have been four clusters of piles driven under each leg. This overhead carrier hangs at an angle of about 30° from the horizontal, the river end being the lower. At each end of this carrier there are a number of pulleys, upon which are operated the wire cables to handle the 5-yd. clamshell bucket.

A four-drum engine is used to operate this clamshell bucket. One man operates all the machinery connected with this bucket. The river end of the overhead trolley system extends out sufficiently from the river to enable the clamshell to be lowered directly over the barge after it has been placed in front of the plant by the tug.

The overhead trolley system is placed at right angles to the river and the sand and gravel is transported to the bins by simply raising the clamshell until it comes in contact with the hook in the overhead trolley system. As soon as the contact is made with this hook, motion away from the river is commenced and the material in the bucket can be dumped at any point desired along the entire length of the overhead trolley, this being at the command of the engineer.

On the land side of the tower supporting the overhead trolley are built the bins for the receiving, washing and storing of the various kinds of sand and gravel acquired.

The gravel is dumped about halfway on the overhead trolley into a large hopper. At the bottom of this hopper is a gate; directly under the gate is a belt conveyor, which operates over concave rollers. In the concave belt is dropped the gravel by means of the gate. This conveyor runs at an angle of about 45° to the overhead trolley, and at its end is another hopper smaller than the first one, but worked in the same manner, over which all of the gravel is carried to a second belt conveyor of the same character as the first, which operates at right angles to the first conveyor and deposits the gravel as it comes from the barge into the chute, where the water is turned on the sand and gravel for the first time.

The gravel then is washed down various chutes and sluiceways and over different mesh screens to separate the finer gravel. As the gravel is separated by this different mesh screening, it is carried through by means of sluice boxes to the proper bin, and there deposited ready to be loaded into the cars at any time. This is done by simply opening the gates placed in the bottom of the bins, which are built sufficiently long and with a sufficient number of gates to load an average length car at one spotting.

The waste water carrying the sand goes through a large box, which has an outlet near the top. This box has a movable bottom and as the sand goes into the box it is dumped directly into the bin. The gravel turned out may contain any required amount of sand. That is, one kind of gravel used for roofing purposes is entirely free from sand and is supposed to go through a screen that has a mesh of ⅝-in. to ¼-in.

The gravel that goes through a screen from 1 in to ¼-in. is called binder gravel, and is used for building purposes, where a clean gravel is required.

The gravel furnished for concrete purposes, where it has not been washed, usually contains from 25 to 45% of sand, depending upon the order given. The gravel furnished the railway company for ballasting tracks contains from 25 to 35% sand and is free from all large rocks or foreign material. The track facilities consist of three parallel tracks, each of which extends sufficiently far beyond the bin to hold six cars. If only one kind of gravel is being loaded at a time, the tracks are of sufficient length to enable 30 cars to be loaded, but it is necessary for the switch engine to make a shift of cars.

The plant is operated by a superintendent, first and second engineer, blacksmith and helper, timekeeper and various help needed around the plant and on the barges. This force is exclusive of the forces employed on the tug and on the dredges. Under favorable circumstances the capacity is from 2,000 to 2,500 cu. yds. of gravel per day of 12 hours. A barge of 250 cu. yds. or 300 cu. yds. can be unloaded in from 50 minutes to one hour.

The tracks, before they reach the plant, have been built up on a pile trestle for a distance of about 200 ft. In fact, all the tracks around the plant proper are supported by creosoted pile trestles.

GRAVEL WASHING PLANT; L. S. & M. S. RY.—The gravel from the pit at Pleasant Lake is a fine gravel,

*See articles in Engineering News, Aug. 6, 1908, p. 148, and Aug. 1, 1907, p. 105.

mixed with much sand, some stone and boulders and a minimum amount of clay and loam. The object in washing the pit-run gravel is to remove all the clay and loam, to crush the stone and boulders for ballast and to separate the sand from the gravel, loading the sand in cars on one track and the washed gravel in cars on another track. The stripping is done by grading machines and the material wasted.

The gravel is loaded by means of a 75-ton steam shovel using a 3½-yd. dipper. The loading face is 40 ft. The material handles well. It is loaded into 40-yd. steel center dump ballast cars of 100,000 lbs. capacity. A maximum of 125 cars have been loaded in one working shift of ten hours, in which the shovel was actually working 7½ hours. Two engines and crews are used to spot the cars at the shovel, haul the gravel to the washer and dump these in the hopper there. The cars are hauled up a stiff grade.

The plant is a wooden trestle structure on concrete foundations. It is driven by a 200-HP. steam engine. The water is supplied for this washer and engine by a 10-in. single-stage centrifugal turbine pump, rated at 2,400 gals., against a 90-ft. head. The pump has a 16-in. suction, 750 ft. long and 12-ft. lift. A test shows that 105 I. HP. is required to drive the pump and 132 I. HP. for operating the entire plant. About 1,700 gals. of water are used per day in actual operation.

The conveyor for the pit-run or raw gravel has a maximum capacity of 5,000 cu. yds. per day of ten hours. The gravel is elevated but once, and is discharged together with the water for washing on a flume 6 ft. wide and 8 ft. long. The water is allowed to escape from an 8-in. pipe through a "duck-bill" nozzle. This flume discharges on a bar screen with 2-in. spacing and a ¾-in. mesh wire screen below and parallel to it. The bar screen removes all stone and boulders, which at once pass to a rock crusher, where the stones are all crushed small enough for ballast and returned to the bar screen again until all passes through into the ballast, thus improving the quality of the finished output. The materials having passed through the bar and ¾-in. screen pass successively over or through a 3-16-in. and ⅛-in. mesh, respectively. The gravel passing over these screens passes to the ballast cars and the sand to sand cars.

The separation of the water from the sand in these large quantities gave some trouble at first. The sand settles in a funnel with a valve at the bottom. The water and sand are admitted. The water flows over three sides of the square funnel and is wasted. When the funnel is nearly full of sand the attendant opens the valve and allows the sand to escape into the bin below. Only stationary screens are used; revolving screens have proven unsatisfactory. The maximum capacity of this plant is 4,000 cu. yds. of raw or pit-run gravel per day of ten hours.

About 40 men are employed. This includes one steam shovel crew, four train crews and several men calking cars with lath, shingles and hay to make them hold wet sand.

The cost per cubic yard of the washed gravel varies much with the percentage of washed gravel obtained from the pit-run gravel. Some pits show 40%, some 55% of washed gravel. Others show 65%, while some pits promise to show 90% of washed gravel. The market for the sand has a considerable effect upon the net price of the finished product. Of course, the amount of stripping and the cost of the land are important elements. No general rule is safe, but it is not unreasonable to expect that pits may be found where the washed gravel would cost about twice as much as the raw or pit-run gravel.

Stone and Gravel Ballast on the C., C., C. & St. L. Ry.

The stone ballast on cars on our track costs 59 cts. and 48 cts. per cu. yd. Gravel ballast on cars, including all costs, ranges from 5.62 cts. to 13.9 cts. per cu. yd.

Stone ballast cost to put under track (in 1908) 31.9 cts. per cu. yd. Gravel ballast cost 11.8 cts. per cu. yd., the amounts of lift and train service being practically equal.

Tie renewals in stone ballast averaged 16.8 cts. per tie, and in gravel ballast 10.3 cts.

The ballast cross-section for stone, with a 12-in. lift, requires an average of 3,380 cu. yds. per mile. Under the same conditions a gravel cross-section having 3,680 cu. yds. per mile is used. Results have indicated that the stone cross-section might be even further reduced and obtain results so far as maintaining surface is concerned equal to that of gravel. It may be said, therefore, that for the same conditions the volume of stone required may be 10% less than gravel.

VERY HIGH WINDS prevailed on April 7 throughout the section east of the Mississippi and north of the Ohio River. Many houses were wrecked, factory buildings injured, chimneys overthrown, and in some districts telegraph, telephone and power wires blown down. The main building of the Toledo-Massillon Bridge Co., at Toledo, Ohio, a steel-frame mill-building, 100 × 400 ft., had the roofing plank torn off one side of the roof.

A Gravel Washing Plant on the Richmond, Fredericksburg and Potomac R. R.

By E. M. HASTINGS.*

The Richmond, Fredericksburg & Potomac R. R. Co. has recently completed and put into operation a plant for the purpose of washing gravel for ballast. It is located about midway between Richmond and Washington, five miles south of Fredericksburg, in Spottsylvania County, Va., on the large gravel lands owned by the railroad company, along what is known as Massaponax Creek. The company is fortunate in having been able to obtain at this point, midway of its line, an immense deposit of gravel of the finest quality. The gravel lies from 10 to 20 ft. deep over quite a large area.

Work on the plant was commenced the latter part of July of the past year, and was pushed as rapidly as possible so as to have it completed before bad weather set in. This was done, the plant being put in operation the latter part of November.

The plant consists of a large concrete hopper into which the pit run gravel is dumped, from which it is carried by a pan conveyor having a speed of 30 ft. per min., or 120 to 150 cu. yds. per hr., on an incline of 30°, to the top of the trestle some 45 ft. high, where it is discharged into a steel-lined box, 6 × 3 ft. in plan and 1 ft. deep in front, or at the chute. The water, discharged from a flat nozzle, 1 in. wide and 24 ins. long, connected to a 6-in. discharge pipe, strikes the gravel as it falls into the box, washing it down over a steel-lined chute 6 ft. wide and 8 ft. long, with a slope of 3 ins. to the foot. It was found necessary in order more completely to wash the gravel to place a series of rods across the chute, making the gravel tumble over them, thereby retarding its progress and obtaining a more complete washing.

At the end of this chute there is a double screen placed at an angle of about 45° with the chute. The screens are about 9 ins. apart, and are of double crimped wire cloth. The first of No. 6 wire, one mesh to the inch, the second of No. 10 wire, two meshes to the inch. A bar screen has been placed in front of the first screen to reduce the wear. All gravel that does not pass these two screens falls into the ballast bin, which is 36 ft. long and 12 ft. wide, and about 12 ft. high. The lower 6 ft. of this bin is sloped all ways toward the center, so that the gravel will fall by gravity through the openings in the bottom. (Fig. 2.)

All of the material which passes these two screens along with the water falls upon a second steel-lined chute which is 8 ft. wide, 9 ft. long, and on a slope of 2 ins. to the foot. From this chute the material is discharged against another screen, of double crimped wire cloth, of No. 12 wire, four meshes to the inch. This screen takes out practically everything larger than ⅛-in. in diameter. All material which does not pass this screen falls into the ballast bin also.

The material passing the screen is carried over another steel-lined chute about 10 ft. wide and 7 ft. long, where it is discharged as sand into a settling tank about 12 × 13 ft. and 3 ft. deep. On the side of this tank opposite this chute is the waste flume where the water is carried off and discharged on the bed of the gra[illegible] pit where the gravel had been previously exca[illegible]ed.

The settling tank is water-tight an[illegible]s fitted at the bottom with two conical steel l[illegible]ers (Fig. 3) 6 ft. in diameter at the top an[illegible]0 ins. in diameter at the base, 5 ft. deep. Th[illegible]ttoms of the steel cones are fitted with a ste[illegible]one plug which makes them nearly water-[illegible]ht. The cone plugs are set from the top of [illegible]e settling tank by a set screw which works [illegible]long rod running through the center of the co[illegible] and are raised and lowered by a lever wo[illegible]g immediately under the set screw and thr[illegible]h a fulcrum at the side of the settling tank. This side of the tank is boarded over so that [illegible]e levers are easy to handle. The idea in hav[illegible]g two of these conical hoppers was to grade th[illegible]sand, the coarse sand settling in the first hopp[illegible] and the fine sand in the farther one, it has [illegible]en found that this is the case, there being a [illegible]distinct difference in the two grades of sand. The sand in settling into these two hoppers naturally loses a great deal of water, it being squeezed out as the sand settles to the bottom of the [illegible]one, consequently when the cone plugs are dropped the sand runs into the cars with very little water;

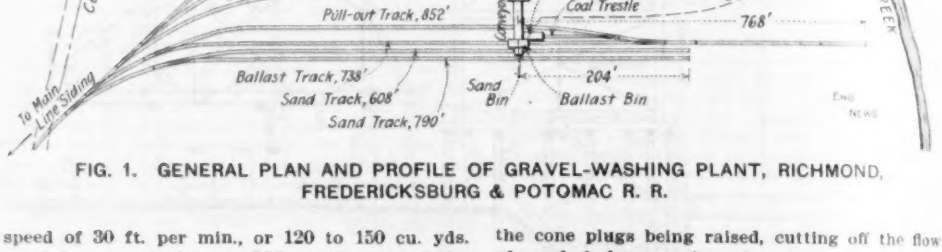


FIG. 1. GENERAL PLAN AND PROFILE OF GRAVEL-WASHING PLANT, RICHMOND, FREDERICKSBURG & POTOMAC R. R.

the cone plugs being raised, cutting off the flow of sand, before much water can come through. It has been found that this is an excellent quality of sand, suitable for all purposes, as building sand, concrete sand, and an excellent engine sand.

The ballast bin is steel-lined throughout and has three openings at the bottom, fitted with 20 × 20-in. rack and pinion valves, spaced so as to empty into the center and two ends of the ballast car, giving a uniform loading. The material from the screens is distributed in the ballast bin about equally over the three openings; this is accomplished by dividing the space at the end of the screens into three equal parts. The material from the two end thirds of the screen strikes on a steel chute, which diverts it from the center, causing it to fall into the ends of the ballast bin, while the material from the center third falls directly into the center of the bin.

The pans on the pan conveyor are 48 ins. wide and 4½ ins. deep over the axles, and 7 ins. deep between the axles. The conveyor is 86 ft. on centers, is composed of 121 links. It is driven by a 25-HP. engine, located immediately under the head shaft, on the ground level, power being transmitted by a 1⅛-in. manila rope drive.

The water is brought from the creek through a gravity canal 900 ft. long (Fig. 1) to a concrete-lined well, 7 × 5 ft., and 11 ft. deep; the bottom of the well being 4 ft. lower than the creek at the intake. This canal is 20 × 20-in. open wood flume for 500 ft. where it runs into a 20 × 20-in. wood box, covered by some 8 ft. of earth. This box is about 370 ft. long, where connection is made with an 18-in. terra cotta pipe, which runs under the engine foundation into the well, which is located right next to the engine. In this well is set a steam pump, with a 6-in. suction and a 5-in. discharge. This pump has a capacity of from 800 to 1,200 gals. per min. The discharge pipe was increased from 5 to 6 ins. to overcome frictional resistance due to two right angle turns necessary to place the discharge nozzle in the desired position.

Steam is furnished by a 90-HP. return tubular boiler, which is located under the same roof as the engine and pump. In this house is also located

*Resident Engineer, Richmond, Fredericksburg & Potomac R. R., Richmond, Va.

a small pump with a 2-in. discharge, which forces the water to a 25,000-gal. tank about 1,400 ft. distant for work and ballast train engine supply.

The concrete hopper (Fig. 4), into which the pit gravel is dumped, preparatory to washing, is 18 ft. 6 in. high above the foundation, 36 ft. long, and 12 ft. wide inside, the outside walls are 2 ft. thick. The inside of the hopper slopes from the top all ways toward the center opening, which is 18 ins. × 30 ins., and feeds to the conveyor. The sloping sides of the hopper are 6 ins. thick, reinforced with from ½-in. to 1½-in. iron rods, spaced about 18-in. centers and bent over into the 2-ft. outside walls. These rods came from an old timber Howe truss bridge, which was dismantled several years ago. The track on the hopper is carried on 12 × 14-in. wood stringers, one of which is immediately over the outside wall, and the other carried on 12 × 14-in. cross-stringers, spaced 6 ft. c. to c., and embedded in the outside walls. The track over the hopper is fitted with a bar screen, bars spaced 4½ ins. apart, so as to prevent roots, stumps or large lumps of clay from being carried to the washing plant.

The approach to the hopper (Fig. 1) is on a 2% grade, ascending, which terminates at a point 150 ft. from the end of the hopper, thence by a 1% descending grade, which continues over the hopper, where it breaks into a 2.5% descending, then to a 5% descending grade for about 150 ft., thence to an 18% ascending grade. At the junction of the 5% and 18% grades there is located a spring switch, the track leading away from the switch being on a descending grade to the pit level, the idea being to do the most of the shifting by gravity. The loaded cars after being pushed up the 2% approach to the hopper, are unloaded, dropped down the 5% grade by gravity, and up on the 18% grade, which gives them a kick back through the spring switch and down to the pit level, where they are taken by the engine to be reloaded. The idea for this scheme was gotten from the Lake Shore & Michigan Southern Ry., and is plainly shown on the profile of tracks. Gravel is loaded from the bank by a 1¾-yd. dipper steam shovel into ballast cars.

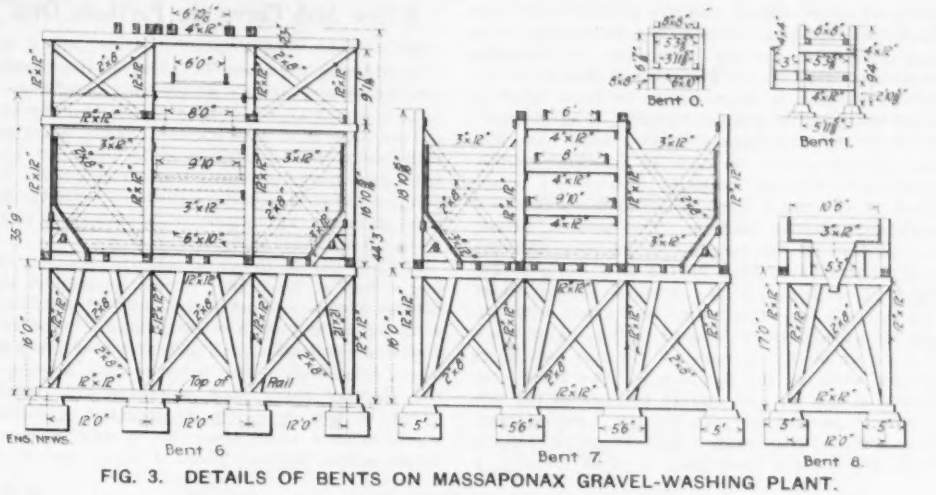


FIG. 3. DETAILS OF BENTS ON MASSAPONAX GRAVEL-WASHING PLANT.

The track layout for the ballast tracks and sand tracks was designed so as to do all the shifting possible by gravity. The empty ballast cars and sand cars stand to the north of the plant and are dropped by gravity under the ballast and sand bins, where after being loaded they drop on down beyond the plant.

The ballast track has a capacity of about 16 cars below the bin. A pull out track, connected to the ballast track at both ends, was laid so that the loaded cars could be pulled out without interfering with the empties standing above the ballast bin.

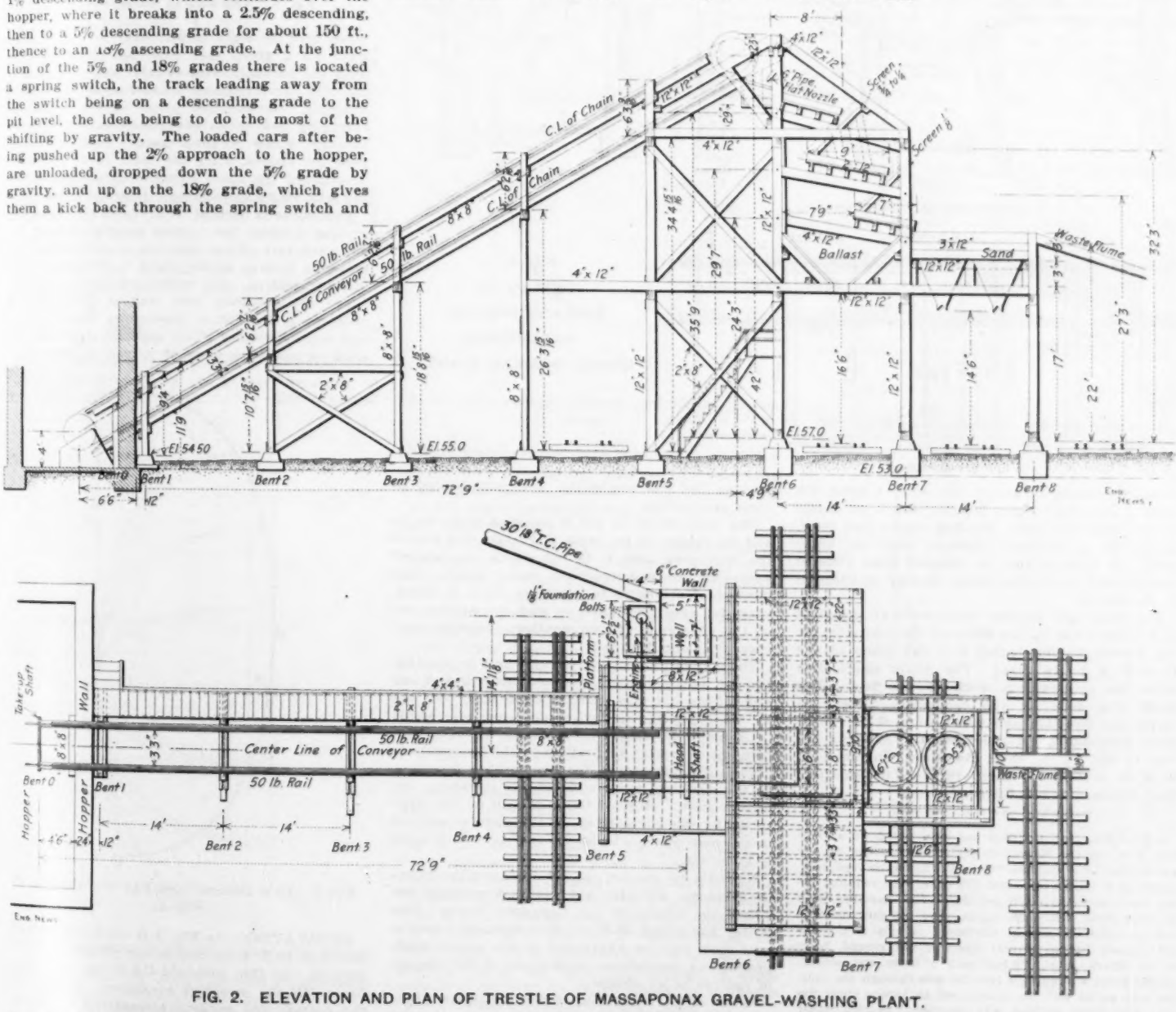
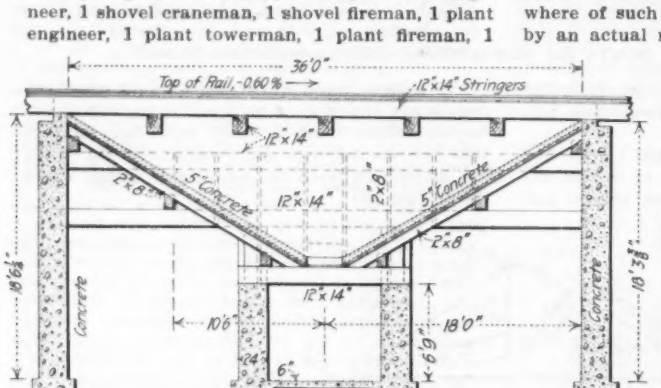


FIG. 2. ELEVATION AND PLAN OF TRESTLE OF MASSAPONAX GRAVEL-WASHING PLANT.

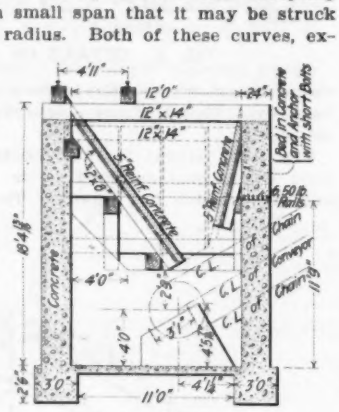
The foundations are all of concrete, made from the pit run gravel, without screening, foundation concrete mixed 1:8, and neat work 1:6.

The plant has been in operation since the lat-

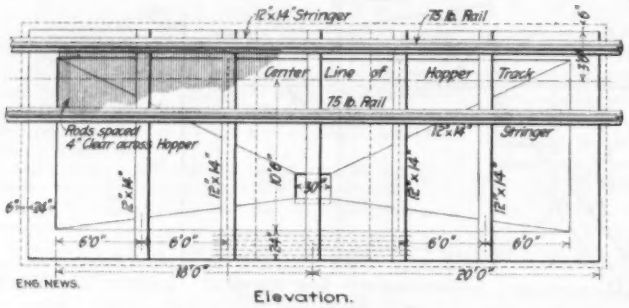
ter part of November, and the product is all that could be expected. It has been found that it is impossible to operate the plant in freezing weather. During the summer months it is expected to have a daily output of from 1,000 to 1,200 cu. yds. of washed ballast. It is intended to cover the 112 miles of double track line with the washed gravel as soon as possible, thereby securing a dustless roadbed. The ballast is applied in the usual way, to conform to the new standard roadbed section. The present ballast is cut out to the bottom of the ties and the washed gravel dumped in, the idea being to get about 3 to 4 ins. of the washed ballast under the ties. It has been found that about 3,000 cu. yds. of washed gravel is used to the double track mile; that is the average of the first five miles of the work so far completed. The force employed at the pit and washer consists of the following: 1 general foreman, 1 clerk, 1 shovel engineer, 1 shovel craneman, 1 shovel fireman, 1 plant engineer, 1 plant towerman, 1 plant fireman, 1



Longitudinal Section.



Cross Section.



Elevation.

FIG. 4. DETAILS OF TRACK HOPPER OF MASSAPONAX GRAVEL-WASHING PLANT.

hopper foreman, 1 gravel bin man, 1 sand bin man, 1 car rider, 3 men around cars, 3 pit hands around shovel, 1 cook, spotting engine and crew, consisting of engineer, fireman and one train hand. A force of men is required from time to time to shift tracks for shovel loading, in addition to the above.

The plans and general detail were all designed and worked out at the office of the company, by the writer, having before him the plans of the L. S. & M. S. Ry. plant. The writer also looked after the construction work in the field. The work was done by the company's forces, all under the direction and supervision of Mr. S. B. Rice, Roadmaster of the company. Thanks are due to Mr. H. H. Ross, Assistant Engineer, L. S. & M. S. Ry., for much valuable information, blue prints and helpful suggestions.

A 3,200-FT. DRILL-HOLE has been put down at Bisbee, Ariz., by the Warren Realty & Development Co. It was drilled by a Sullivan "Class C" hydraulic feed drill, removing a 1⅛-in. core, and 375 days were required for the work, one 9-hr. shift per day. The diamonds were set with small clearance, 1/64-in., and the fact that the hole is quite straight is attributed to this fact. The drill passed through several layers of soft ground, down to the 580-ft. level. When such a layer was struck, cement grout was pumped into the hole through the rods, the rods pulled and the cement left to harden until the next day, when drilling was resumed. In this upper section of the hole the average length drilled per bit was 8 ft., but lower down an average of 30 ft. was attained. The Sullivan Machinery Co., in its publication "Mine and Quarry," credits this as the deepest diamond-drill hole in the United States.

A New Arch Curve, the Parabolic Oval.

By CHARLES WORTHINGTON,* M. Am. Soc. C. E.

In choosing the curve for an arch, the designer usually arrives at one which meets his ideas of artistic appearance and then proportions the arch on the lines thus determined, possibly modifying this curve as he progresses in order to keep within the limits of economical construction. The adopted curve is usually a parabola with vertical axis, a circle, an ellipse, or a composite curve made up of a series of circular arcs.

Of these curves the parabola, with vertical axis and vertex at the crown, is well adapted to segmental arches of slight rise, and is easily constructed by the method of ordinates. But it is altogether inflexible, the span and rise fixing the curve completely. The same remark applies to the circular curve, and moreover the circular curve is not so easily constructed, excepting where of such small span that it may be struck by an actual radius. Both of these curves, excepting the full semicircle, are very limited in their application.

The semi-ellipse is not a pleasing curve in itself by reason of its being and appearing flat at the haunches, and it is not easily constructed excepting for comparatively small spans. The method of ordinates is laborious, as it is necessary, for every ordinate, to find the square root of the difference of two numbers, usually numbers with long decimals.

The composite curve of circular arcs is probably the one most commonly adopted for arches of any size. This curve is determined first by the eye of the designer, approximately, and afterwards by a series of circular arcs, found by trial, conforming as nearly as possible to the approximate curve. This process is, for large arches, laborious in the drafting room and difficult in laying out on the work. Most of the radii will be too large to strike the circle from actual centers, and, as in the case of the ellipse, the method of ordinates is laborious.

Normals to the curves, for instance the joints in masonry, are also not easily determined for either the ellipse or the composite curve. The writer has found, further, that composite curves may look well on paper and in the actual work present an appearance of flatness if the change of radii is at all abrupt.

In an effort to find an easier and more practical solution of a very difficult example of such a composite curve, a long span ornamental steel arch with not two but many curves all converging towards the crown, the writer discovered a curve which is as easy to construct by the method of ordinates as the parabola, is similar to the ellipse without being flattened at the haunches, and, being a true mathematical curve from springing line to crown, is free from all abrupt changes in curvature. It is also flexible when used for segmental arches; instead of being fixed for a given span and rise, as is the case with the parabola with vertical axis and the circle, this curve requires another condition, as, for example, an assumed slope of the curve at springing line, or an assumed intermediate point through which it shall pass. Moreover, when used for arches, after the soffit curve has been determined the upper curve or curves that define the arch ring follow directly from the soffit curve.

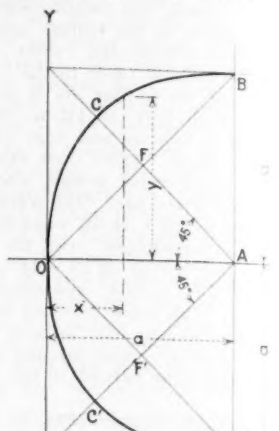


Fig. 1. The Pair of Initial Parabolas.

This curve is derived from the parabola by distorting it about the normal passing through the one extremity of its principal parameter, as the ellipse is derived by distorting a circle about any of its diameters. The writer has named this new curve the *parabolic oval*, and in the following presents a description illustrating its derivation and some examples of its application, giving also working equations whereby it may be used.

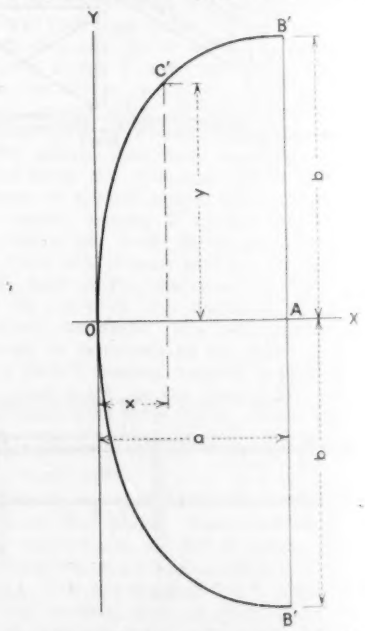


Fig. 2. Oval Derived from Pair of Parabolas of Fig. 1.

DERIVATION.—In Fig. 1 is shown the original parabola *OCB* from which the parabolic oval is derived. Of this parabola *CA* is the axis, *F* the focus, *OB* the principal parameter, and *OX*, *OY*, the normal and tangent respectively at the extremity of the parameter. The normal *OY* makes an angle of 45° with the axis *CA*, and 90° with the tangent *OY*.

The equation of this parabola *OCB*, referred to

*Engineer and Architect, 229 West 101st St., New York City.

OX and OY as axes of coordinates, and O as origin, is,

$$y = \pm \sqrt{\quad} - x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The plus sign before the first term of the second member of this equation represents that portion of the curve starting at origin O, and going upward to the right therefrom. The minus sign represents that portion (not shown in the drawing) starting at the origin O and going downward therefrom; the latter portion of the curve is not used herein and will be ignored.

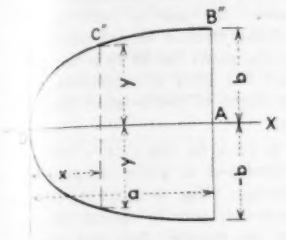


Fig. 3. Prolate Oval Derived from Fig. 1.

The parabola shown below the horizontal axis OX of coordinates in Fig. 1 is symmetrical about that axis in all respects with the one above it, and its ordinates are the same in value, but of opposite sign. The equation, then, of the complete curve shown in Fig. 1, including the two wings shown, but excluding the portion of each curve represented by the minus sign of the first member of the second term as just described, may be written,

$$y = \pm (\sqrt{4ax} - x). \quad \ldots\ldots\ldots (2)$$

In Fig. 2 is shown an example of the parabolic oval derived from the parabolas shown in Fig. 1 by modifying each ordinate (y) of that curve in the ratio b/a for the corresponding ordinate of the new curve. The equation of this new curve, referred to same origin and axes as before, is,

$$y = \pm \frac{b}{a} (\sqrt{4ax} - x) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where a and b are the semiaxes of the oval.

This equation, (3), is the general equation of the parabolic oval, referred to the apex O of the curve as origin, the a-axis as axis of abscissas, and the tangent O as axis of ordinates.

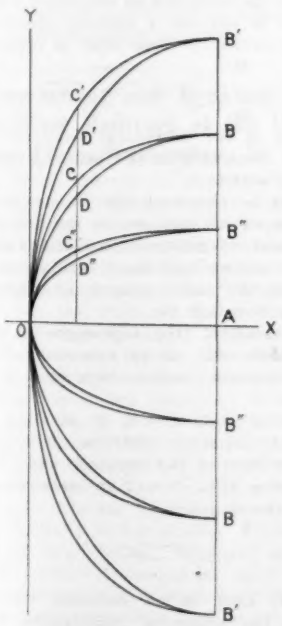


Fig. 4. Comparison of Parabolic Oval with Ellipse.

PLOTTING THE CURVE.—To construct a parabolic oval upon given semi-axes a and b, assume in equation (3) convenient values of x and find the corresponding values of y; then plot as indicated in Fig. 2. By a simple process of tabulation, the use of a tables of squares, and possibly a slide rule, these ordinates may be determined very quickly. For example, assuming that $a = 100$ and $b = 150$, this tabulation would be as follows:

1.	2.	3.	4.	5.
x	$\sqrt{x}$	$\sqrt{4\,ax}$	$\sqrt{4\,ax} - x$	$b/a\ (\sqrt{4\,ax} - x) = y$
4	2	40	36	54
9	3	60	51	76.5
16	4	80	64	96
25	5	100	75	112.5
36	6	120	84	126
49	7	140	91	136.5
64	8	160	96	144
81	9	180	99	148.5
100	10	200	100	150

The figures in Column 1 are assumed at will; column 2 is taken directly from memory or from one of the numerous handbooks giving square roots of numbers; column 3 is found by multiplying Col. 2 by the constant quantity $\sqrt{4a}$; column 4 is found by subtracting Col. 1 from Col. 3; and Col. 5 is found by multiplying Col. 4 by the constant quantity b/a.

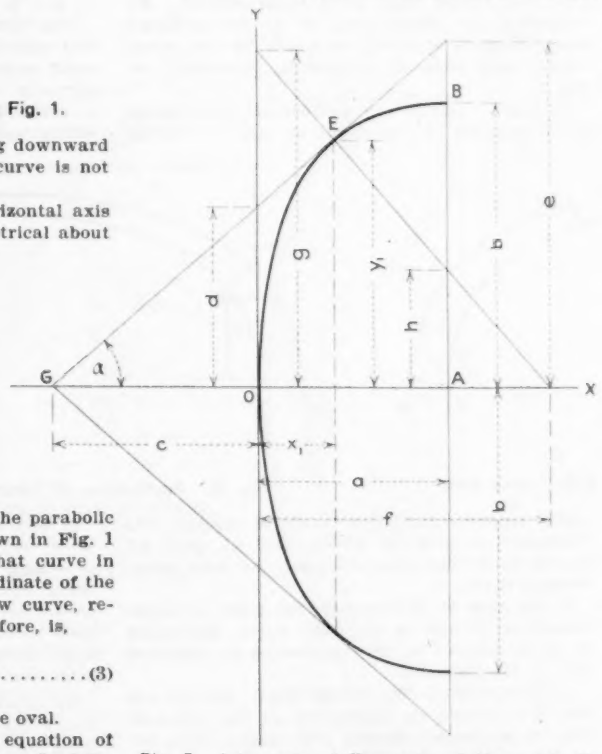


Fig. 5. Intercepts of Tangent and Normal to the Curve.

It will be seen that a judicious choice of values for x permits a very quick solution of the problem, especially when a and b are in round numbers, as they usually are.

PROLATE OVAL.—In Fig. 3 is shown another example of the parabolic oval, derived from the curves of Fig. 1 in the same manner as described for Fig. 2, only that in this case b is smaller than a, whereas in Fig. 2 b is greater than a; the general equation (3) being the same in either case, with only different values for the constant b.

By further extending the curves shown in Figs. 1, 2, and 3, the two wings would come together, intersecting on the horizontal axis of coordinates at a point distant $4a$ from the origin O, and forming a top shaped curve.

CURVE COMPARED WITH ELLIPSE.—In Fig. 4 are shown together, for the purpose of direct comparison, the same parabola OCB of Fig. 1, and the corresponding circle ODB of radius OA, also the parabolic ovals $OC'B'$ and $OC''B''$ of Figs. 2 and 3, respectively, with the corresponding ellipses $OD'B'$ and $OD''B''$ derived from the circle ODB. It is interesting to note that the parabolic oval lies above the ellipse of same semi-axes, without the flattening at the haunches that mars the appearance of the ellipse.

As a matter of interest, the radius of curvature of the parabolic oval at the points O and B is just twice that of the corresponding ellipse at these same points.

TANGENT TO OVAL.—In Fig. 5 is shown the tangent to a parabolic oval at any point, as E, on the curve.

Let (x_1, y_1) be the coordinates of the point E on the curve, OEB, represented by Eq. (3). The tangent at E makes with the axis of abscissas, OX, an angle α whose tangent is expressed by the equation.

$$\tan \alpha = \frac{b}{a} (\sqrt{a/x_1} - 1) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

And the equation of the tangent is, then,

$$y = y_1 + \frac{b}{a} (x - x_1) (\sqrt{a/x_1} - 1) \quad \ldots\ldots\ldots\ldots\ldots (5)$$

Its intercept c on axis OX is given by the equation,

$$c = x_1 - \frac{a y_1}{b (\sqrt{a/x_1} - 1)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Its intercept d on axis OY, is given by the equation,

$$d = y_1 - \frac{b}{a} x_1 (\sqrt{a/x_1} - 1) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Its intercept e on AB is given by the equation,

$$e = y_1 + \frac{b}{a} (a - x_1) (\sqrt{a/x_1} - 1) \quad \ldots\ldots\ldots\ldots\ldots (8)$$

NORMAL TO OVAL.—In Fig. 5 is shown also the normal to the parabolic oval at any point as E on the curve. Let (x_1, y_1) be the coordinates of the point E. The equation of the normal at point E of the curve is,

$$y = y_1 - \frac{a}{b} \frac{x - x_1}{\sqrt{a/x_1} - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Its intercept f on axis OX is given by the equation,

$$f = x_1 + \frac{b}{a} y_1 (\sqrt{a/x_1} - 1) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Its intercept g on axis OY is given by the equation,

$$g = y_1 + \frac{a x_1}{b (\sqrt{a/x_1} - 1)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Its intercept h on AB is given by the equation,

$$h = y_1 - \frac{a (a - x_1)}{b (\sqrt{a/x_1} - 1)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

CURVE TANGENT TO A GIVEN LINE.—The method of constructing a parabolic oval that will be tangent to a given line at a given point on that line is as follows: Let GE, Fig. 5, be the

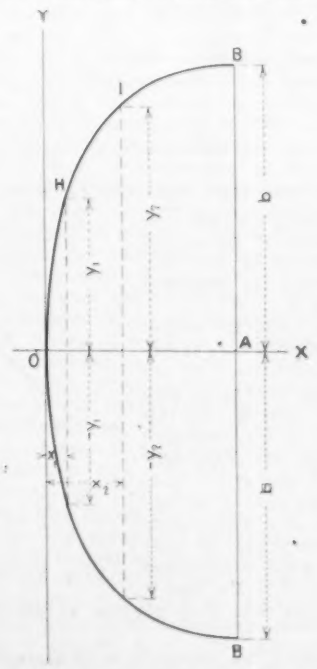


Fig. 6. Passing a Parabolic Oval of Given Axes Through Two Given Points.

given line, making an angle α with axis OX, and let (x_1, y_1) be the coordinates of the given point E on the line. Since the curve is to pass through the point (x_1, y_1), we have from equation (3) above,

$$y_1 = -\frac{b}{a}(\sqrt{4ax_1} - x_1) \quad \ldots\ldots (3a)$$

And since the curve is to be tangent to GE at the point (x_1, y_1), we have, from equation (4) above,

$$\tan \alpha = -\frac{b}{a}(\sqrt{a/x_1} - 1) \quad \ldots\ldots (4a)$$

By solving Eq. (3a) for b/a, substituting in (4a) and solving for a, then substituting these values of $\frac{b}{a}$ and a in Eq. (3), the required curve will be determined and may be plotted as described for Fig. 2.

In the above equations relating to tangent and normal, the double sign in Eq. (3) has been ignored and the positive sign only considered—representing the upper wing of the curve—in order to avoid confusion in the working equations here derived. The complete symmetry of the curve about the horizontal axis of coordinates enables one to apply to the lower wing of the curve, directly, any relationships determined for the upper wing.

CURVE PASSING THROUGH TWO POINTS.—In Fig. 6 is shown the method of constructing a parabolic oval that will pass through two given points, as H, and I, whose coordinates are (x_1, y_1), and (x_2, y_2) respectively.

Since these points are to be on the curve, we have from Eq. (3) above,

$$y_1 = \pm \frac{b}{a}(\sqrt{4ax_1} - x_1) \quad \ldots\ldots (3b)$$

and,

$$y_2 = \pm \frac{b}{a}(\sqrt{4ax_2} - x_2) \quad \ldots\ldots (3c)$$

By solving these equations for a and b, and substituting in Eq. (3), the required curve will be determined and may be plotted as described for Fig. 2.

FULL CURVED ARCH.—In Fig. 7 is shown an application of the parabolic oval to an arch of full curves. In this case b is the half-span and a the rise of the soffit curve, b' and a' the half-span and rise of the upper curve. The curves are determined by substituting the given values of a and b, and a' and b' in Eq. (3), and then plotting as described for Fig. 2.

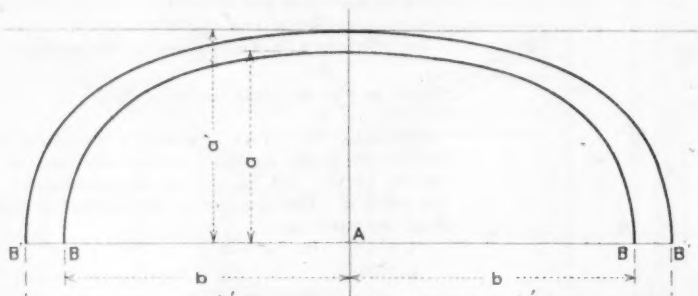


Fig. 7. Application of Parabolic Oval to a Full-Curved Arch.

It is found that parabolic ovals harmonize with each other under wide variations in the proportions of their axes, a feature of much importance where it is necessary to use different spans adjacent to each other in the same structure.

SEGMENTAL ARCHES.—In Fig. 8 is shown an application of the parabolic oval to a segmental arch.

In this case the curve of the arch soffit may be determined by assuming, in addition to the span and rise, either the slope at the springing line, or an intermediate point between springing line and crown. If the slope at the springing line be assumed, the curve will be determined by the process for drawing the oval tangent to a given line at a given point, as described in connection with Fig. 5; if an intermediate point be assumed, the curve will be determined by the process described for Fig. 6.

In determining the upper curve of the arch, the value of a to be used in equation (3) will be that value of a already found for the soffit curve, plus the thickness of the arch at the crown; this will ensure the curves being similar. By assuming one other point, as at its springing line, the value of b may be found for this curve which may then be plotted as described for Fig. 2.

In Figs. 7 and 8, any number of other curves between those shown might be laid out in the same manner, in which case, of course, the thickness of arch at crown and at axis AB should be divided proportionately by each intermediate curve.

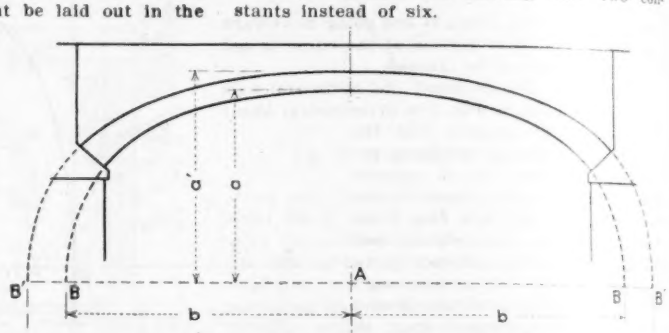


Fig. 8. Application of Parabolic Oval to a Segmental Arch.

If the arch be of masonry, the joints of stone would be normal to the soffit curve, and could be easily located by the application of equations (9) to (12) inclusive.

APPLICATION TO CRESCENT TRUSS.—In Fig. 9 is shown an application of the parabolic oval to a crescent-shaped roof truss. Here one of the curves is determined by any of the above described methods, and the other one similarly determined, its axes coinciding in position with those of the one already determined.

In this case it will generally be desirable, in plotting the curve, or in giving dimensions on the drawings, to assume distances in the direction of BA, as for example between vertical web members of the truss, and to determine the distances vertically to the curves at these points. This can be done most easily by first finding the values of a, a', b, b' by the methods above described; then transferring the origin of coordinates to B and B' for each curve respectively, with the line BA as the new axis of abscissas, and then applying equation (3), with b and a interchanged for one curve and b' and a' for the other.

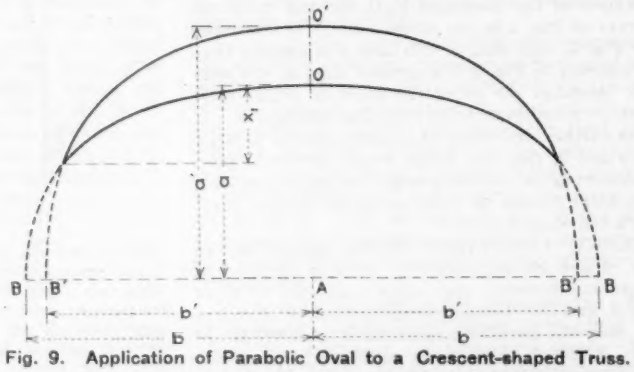


Fig. 9. Application of Parabolic Oval to a Crescent-shaped Truss.

MATHEMATICAL DISCUSSION.—Considered in the light of pure mathematics, the parabolic oval is a combination of two parabolic arcs tangent to each other at the or[illegible] of coordinates, the one above, and the o[illegible] below the axis of abscissas. The derivation [illegible]s equation is of interest.

Starting with the general equat[illegible] of the second degree,

$$mx^2 + nxy + py^2 + qx + ry + s = \quad \ldots\ldots (13)$$

which, as is well known, repres[illegible] always a conic section or one of the limits [illegible] conic section, we first fix the location of th[illegible] curve represented thereby with reference to [illegible]e axes of coordinates, so that it will pass [illegible]hrough the origin of coordinates in a vertical [illegible]ection, pass through the point (a, a) in a horizo[illegible]al direction, and cross the axis of abscissas at [illegible]he distance ac to the right of the origin. We t[illegible] derive the equation,

$$y = \tfrac{1}{2}\,[\pm \sqrt{cx\,(4a + cx - 4x)} - [illegible] + 2x]. \quad (14)$$

This equation is quite as genera[illegible]s the general equation (13), in that it inclu[illegible]s all of the conic sections; but by fixing the p[illegible]tion of the curve in the manner just assumed [illegible]e equation is simplified into one having onl[illegible] two constants instead of six.

It will be observed that equation (14) represents an ellipse, a parabola, or an hyperbola, according as the value of constant c is less than, equal to, or greater than 4. The axis of the curve is in the same position, with reference to the axes of coordinates, as that of the upper parabola in Fig. 1, the curve itself having in general the appearance of that parabola.

By combining the portion of this curve lying above the axis of abscissas, OX, with another lying below this line and symmetrical with the upper one about same, and modifying the ordinates in the ratio b/a as described above for Fig 2, there is derived a general equation of what may be called the *conic oval*, as follows:

$$y = \pm \frac{b}{2a}[\sqrt{cx\,(4a + cx - 4x)} - cx + 2x]. \quad (15)$$

where a is the horizontal semi-axis, and b the vertical semi-axis of the oval, as used throughout this article.

It will be observed that in deriving equation (15) the minus sign before the first term of the right-hand side of equation (14) has been ignored, and the entire right-hand side given the double sign, for the same reasons as stated above in deriving equation (3).

This equation, (15), represents an elliptic oval, a parabolic oval, or an hyperbolic oval, according as constant c is less than, equal to, or greater than 4.

Assuming that $c = 4$, in equation (15), there results an equation identical with equation (3) above, or that of the parabolic oval.

Assuming that $c = 2$ in equation (15), there results the equation,

$$y = \pm \frac{b}{a}\sqrt{2ax - x^2} \quad \ldots\ldots (16)$$

which is that of an ordinary ellipse passing through the origin of coordinates, and having semi-axes a and b coinciding with those of the oval. Thus it is seen that the ellipse is a special case of the elliptic oval.

Assuming further in equation (16) that $b = a$, there results,

$$y = \pm \sqrt{2ax - x^2} \quad \ldots\ldots (17)$$

which is the equation of a circle of radius passing through the origin of coordinates.

For any given values of the semi-axes a and b, there is but one parabolic oval, whereas any number of elliptic or hyperbolic ovals might be constructed upon these semi-axes, depending on the value of the constant c. The parabolic oval is generally the most graceful of this group of curves; the elliptic oval lies below, and the hyperbolic oval lies above the parabolic oval. The lower limit of the elliptic oval is a right line passing through the origin O and the point (a, b). The upper limit of the hyperbolic oval is the pair of intersecting right lines, one passing vertically through the origin, and the other passing horizontally through the point (a, b).

The parabolic oval is represented by a much simpler equation than the other ovals, though under certain conditions the greater flexibility of the more general equation, (15), with its three constants as compared with the two constants of equation (3) will be more useful in solving the problem at hand. The application of Eq. (15) is in reality much easier than would be supposed at first glance; after the numerical value of c has been determined and substituted in this equation it becomes much simplified in form.

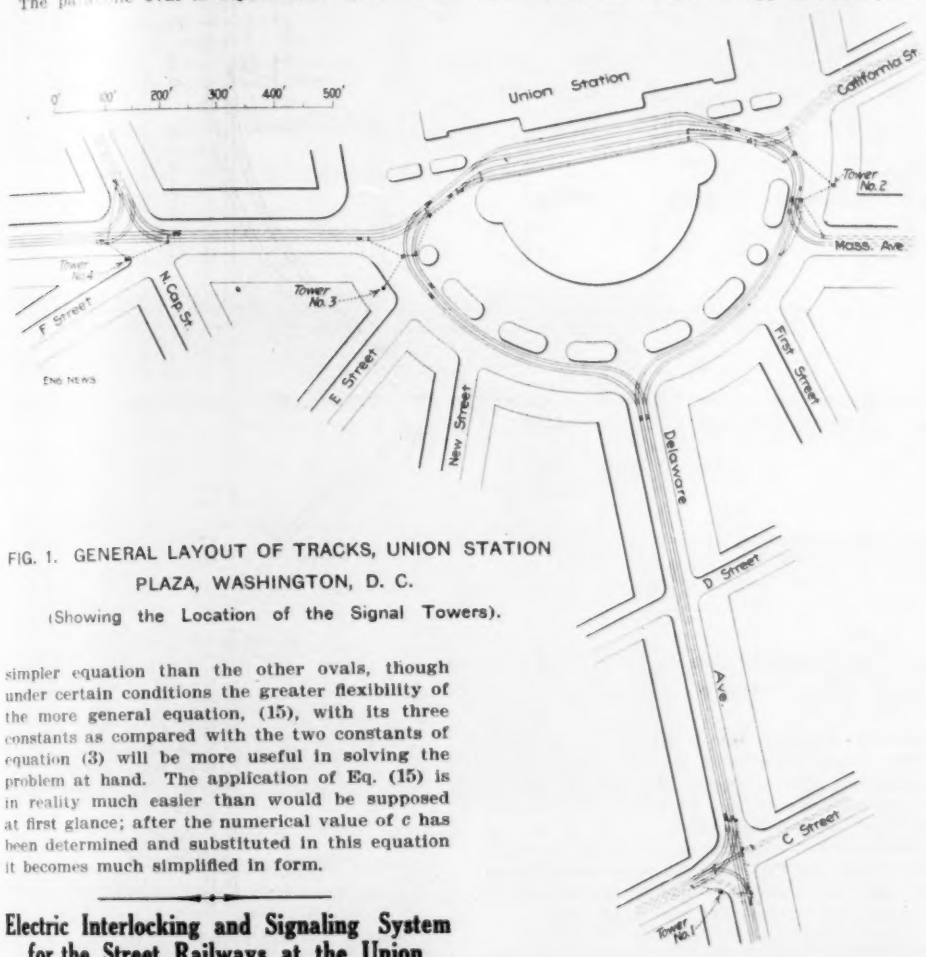


FIG. 1. GENERAL LAYOUT OF TRACKS, UNION STATION PLAZA, WASHINGTON, D. C.
(Showing the Location of the Signal Towers).

Electric Interlocking and Signaling System for the Street Railways at the Union Station Plaza, Washington, D. C.

The new Union Station in Washington, D. C., was built in a part of the city through which few car lines were running at the beginning of construction, and also at such an elevation that fills as high as 30 ft. were required over nearly all of the area now called the Plaza, a park extending from the front of the station to the nearest intersecting streets. It therefore became necessary to reconstruct the whole system of street railways in the immediate neighborhood of the station, in a few instances to get them to grade, but mainly to provide that all lines had access to the entrance. On this latter account there has resulted at several crossings around the borders of the Plaza a complication of tracks all switching into the common track up to the entrance of the station. These tracks are used by cars coming from all directions, operated by different companies, with different kinds of rolling stock, but some uniform system of switching and signaling had to be provided for them all.

At other crossings throughout the city, switching and signaling is carried on by a flagman stationed at the crossing and throwing the switch with the ordinary chain pull. But around the station the complication of tracks and the necessity for more than one man at each junction point to take care of the various directions, led the two railway companies of the city to join forces and to install at five points electric interlocking switching and signal devices, operated, at each point, by one man stationed in a tower near the intersection. So far as we know this is the first occasion for the application of so extensive a system to the operation of street railways, so that a description of the scheme should be a matter of interest.

In Fig. 1 is shown the general layout of the tracks in the immediate vicinity of the station and the location of four of the five signal installations; the remaining one, the most simple of the lot, is at the corner of 1st and B Sts. S. E., several blocks south of the Plaza. It will be noted that the station is approached by four lines of double tracks, the cars from all of which pass partly or entirely around the circular line of double tracks in front of the station, separating there into four lines of track at the entrance. Two of the signal towers are at the entrance of these separate tracks into the joint circle, while the others are farther away from the station at other points of convergence.

The problem to be solved by the system was to put the crossing in the control of one man, so located that he could see the four directions of approaching cars. This system had not only to throw switches and display signals of such throwing but automatically had to control the switches and signals so that the towerman could not send two cars on to intersecting tracks or shift the switch under a passing car. As the street railways of the city of Washington are operated by the underground conduit system of transmission, the switching device had to be designed to shift the slot rail as well as the track.

The most complicated of the five installations is the one at the corner of Delaware Ave. and C St., to which this description will be confined. The other stations are practically the same in design and operation.

METHOD OF OPERATION.—The system adopted is simple from the point of view of steam railway practice, but its application to street railway work constitutes its novelty. In brief, it is an interlocked electric signal and switch system, operated by an interlocking machine, the "control-cabinet," located in a tower commanding a view of all approaches to that crossing. Each switch is thrown by a lever, after which the operator, by another lever, sets the signal to clear from its normal danger position. The cabinet is mechanically so interlocked that no conflicting signal can be thrown once a switch is set. Probably the best explanation of the method of operation is to send a car through the switch marked "1" in diagram of Fig. 2. In this following description the actual switches and signals will be designated by the number in quotes; thus, "2" is signal 2 in the street. The levers in the control box, corresponding to the signals or switches, will be designated as No. 2, or No. 3, etc.

As the car approaches switch "1," it is stopped by the motorman at signal "2," placed just in advance of the switch. This signal consists of two electric lights, one red and one green, placed in a small cast-iron manhole with a grated cover set between the rails and flush with the paving (Fig. 4). The lights are enclosed in a water-tight case and are protected by heavy glass, in turn covered with metal network. Only one light can show at a time, the red or danger signal being normal, so that unless the light is specifically changed by the towerman the motorman must stop his car.

If the switch lies against the car the towerman starts to rotate the lever No. 1 in the cabinet (Fig. 5). This makes contact, completing the circuit to the solenoid that actuates the switch (see wiring diagram in Fig. 2), the mechanism of which is described hereinafter. When the stroke of this switch-control lever is a little over half completed, the corresponding bar in the control box is arrested by a latch under control of a return indication magnet and the lever can be moved no farther. The switch, however, continues in its movement and when it has completed its stroke it makes contact in a circuit through the return indication magnet, lifting the above-noted latch and permitting the signal control lever to finish its stroke. And as the mechanical interlocking in the cabinet prevents any movement of the signal control lever No. 2 until the bar attached to lever No. 1 is at the end of its stroke, the signal "2" cannot be changed clear until the switch movement at "1" has been completed.

The switch once thrown, the towerman presses button No. 2, which, if not locked by reason of some conflicting route being cleared, moves inward. At the start of the movement the circuit to the red light in the signal between the tracks at "2" is broken and toward the end of the stroke the circuit is made to the green light. At the end of the stroke a latch on the signal bar No. 2 drops, thus locking the signal lever in the reverse or clear position. As seen in Fig. 5 this lever works against a compression spring, and the bar is held in the reverse position by the latch, and when this latch is lifted the bar returns to normal. When the signal is set to green the motorman proceeds along his route. When the car is passing out of the crossing, the plow actuates a signal lock contact which completes a circuit through the signal lock coil, lifting a latch on the signal control bar, which, under the spring, moves back to normal. The location of these signal lock contacts is shown on the diagram plan in Fig. 2 and they are illustrated in Fig. 3. In case the wrong switch is thrown to an approaching car which has not passed the switch and the signal is set to clear, the signal can be sent back to danger by the operator lifting the latch bar in the signal box, which will release the signal bar, to be carried back to normal by the compression spring.

From the layout of the mechanical interlocking in Fig. 5, it will be seen that when signal bar No. 2 is at its extreme position, i. e., at clear or proceed, it is locked into switch bar No. 1, so that the latter cannot be moved until the signal bar is released to normal. This prevents throwing the switch while a car is passing over it.

SWITCH-THROWING MECHANISM. — The switch-throwing mechanism is shown in Fig. 8.

The mechanical details of this are the same as those in use in other parts of the city where manual switch operation with a chain pull obtains. To this has been connected a patented device actuated by a solenoid, and by means of a reversing cam-plate movement is given to the switch first in one direction and then in the other. Fig. 7 gives a view of the solenoid and cam-plate box actuating the switch. In this view the solenoid plunger is at its lowest point and the switch toggle accordingly at its extreme left position. When the solenoid is energized and its plunger lifts it carries with it the vertically placed cam-plate with the guide holes. The side of the heart-shaped hole in the center of the cam-plate engages a roller which is attached to a horizontally moving fork that gives movement to the switch through the toggle joint. At the same time two fixed rollers are engaged by the points which form the centers of the V-shaped holes in the cam-plate. It will then be seen that the balance of the movement acts like driving a wedge between the fixed roller and the roller which gives the movement to the switch, the side of the heart-shaped hole forming one side of the wedge and the side of the pointed piece in the V-shaped hole forming the other side of the wedge, so that at the top of the stroke the switch has received its complete throw. At this time the roller which gives movement to the switch rests in the bottom of the heart-shaped hole and the fixed rollers rest in the bottom of the V-shaped hol... When the solenoid is de-energized the ...plate and plunger start to fall back by the fo... of gravity and the plate is guided obliquely by ... V-shaped holes so that at the time when th... xed rollers will clear the points of the V-sha... holes the cam-plate engages the roller wh... transmits the motion to the switch on the top of the heart-shaped hole and to the side of the center. Then the plate rolls along this roller and down the inclined surface of the top of the heart-shaped hole so that the fixed rollers are then on the opposite sides of the V-shaped holes and the movable roller is on the opposite side of the heart-shaped hole from the sides they were on when the upward stroke was started. It will be seen that when the solenoid is again energized that the fixed rollers will run down the opposite sides of the V-shaped holes and the movable roller will be engaged by the opposite face of the heart-shaped hole and motion will then be transmitted to the switch in the opposite direction. When the plunger and cam-plate are at the top of the stroke the switch lever has then reached its locked position previously referred to. This device has been used in a number of installations by its patenting company.

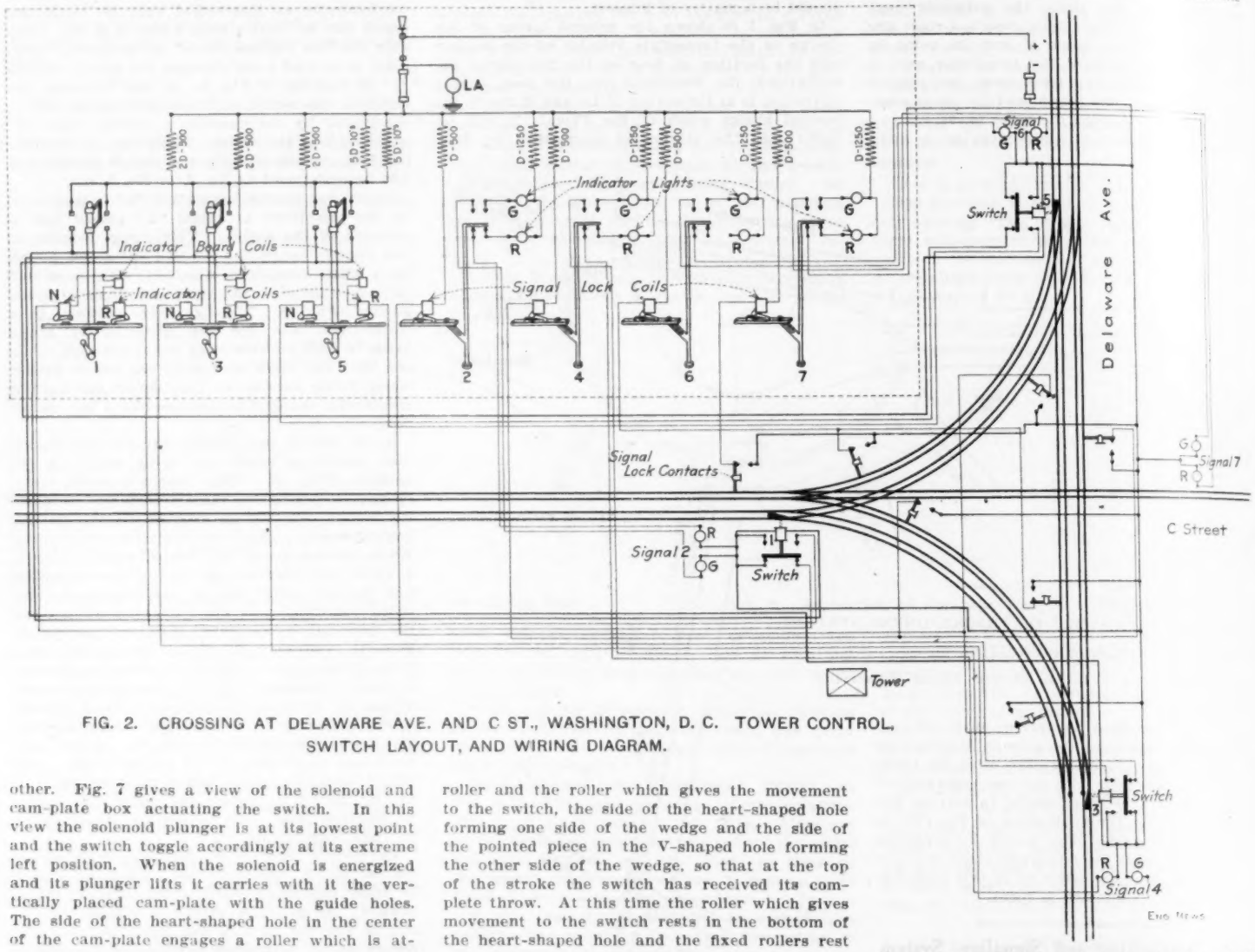


FIG. 2. CROSSING AT DELAWARE AVE. AND C ST., WASHINGTON, D. C. TOWER CONTROL, SWITCH LAYOUT, AND WIRING DIAGRAM.

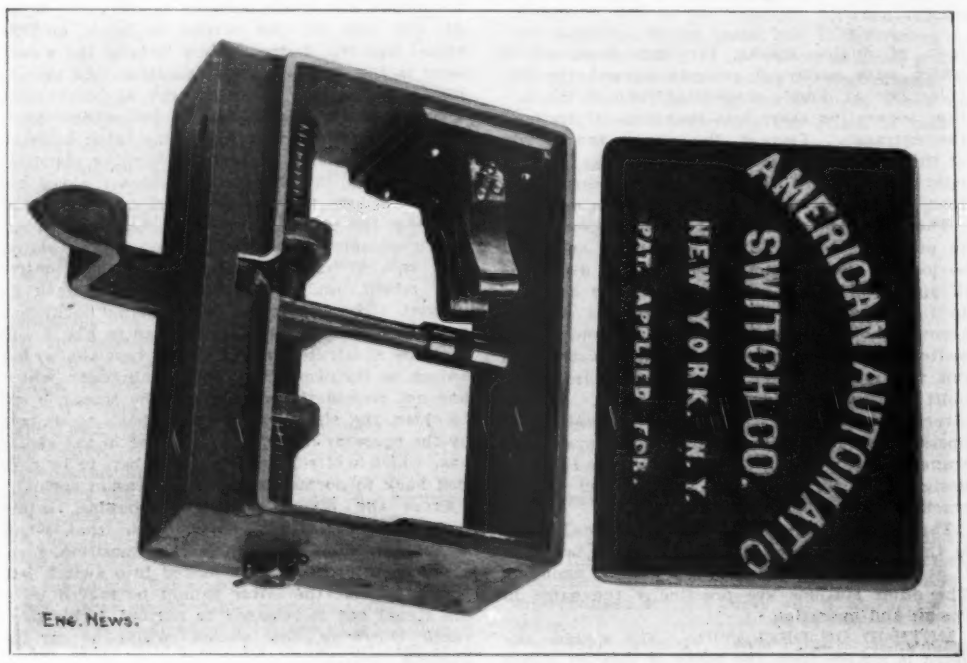


FIG. 3. SIGNAL LEVER LATCH THROWN AS CAR PASSES OUT OF SWITCH.

Simultaneous with the movement of the track rail, a similar motion is applied to a plate under the slot rail, which gives the correct direction to the plow.

The circuit to the solenoid which throws the switch is controlled by a magnetic blow-out quick-break switch. This switch is mounted inside the cabinet and has two contacts respectively on both the left and right-hand side. When either pair of these contacts is bridged by a conductor the circuit is completed to the solenoid. This switch has mounted in the center a pivoted swinging contact which normally hangs ver-

tically midway between the two pairs of contacts, leaving both circuits open, and is forced alternately to the right or left for the purpose of bridging the pair of contacts above mentioned. To the shaft which is rotated by the switch-control lever is attached a cam, and at about one-quarter of the stroke this cam engages the top of the swinging contact and forces it over to where it bridges the circuit to the pair of contacts above mentioned. At about three-quarters of the stroke this cam is removed from engaging this swinging contact and by means of stiff springs the swinging contact is quickly returned to its normal vertical position, breaking the circuit in two arcs across the face of a magnet. When the handle is started in the opposite direction the cam at about one-quarter of the stroke engages the swinging contact on the opposite side and causes the swinging latch to bridge the circuit across the other pair of contacts, and at about three-quarters of the stroke is again released and the circuit is broken the same as just described.

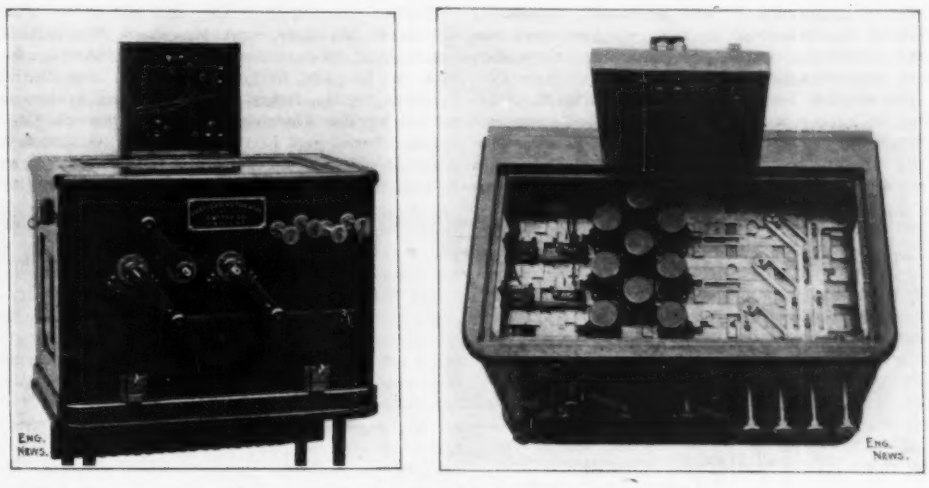


FIG. 5. TWO VIEWS OF CONTROL CABINET.
(Made by the American Automatic Switch Co., New York).

MODEL INDICATOR BOARD.—For the benefit of the towerman, so that he can have before him the exact condition of the switches and signals, there is, at the top of the control cabinet, a model indicator board which follows the actual system in detail both as to switches and signals. In ordinary practice such a board is mechanically operated from the control-box. In this system, however, the model switches on the indicator board are electrically operated from the switches themselves, so that if the switches should be manually operated, outside of the control-box, such a movement is communicated to the indicator board for the information of the towerman. The electrical connections to the board are shown in the wiring diagram Fig. 2.

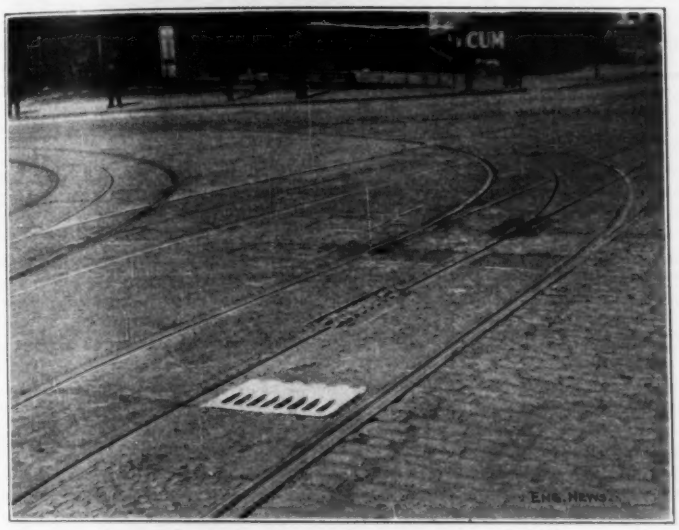


FIG. 4. SIGNAL BOX IN STREET.

TOWER.—The tower is placed at each crossing where a full view of all cars can be had. Special attention has been paid to its design so that it will harmonize with the general design of the station, plaza and the public buildings near by, and will not be too obtrusive. Fig. 6 shows the tower at the corner of Delaware Ave. and C St. looking south toward the U. S. Capitol. The tower itself is 4 ft. in its greatest inside measurement, just large enough for the one towerman and the control cabinet. It is covered with pressed copper, which has been rusted green by an acid and mounted on a cast-iron decorated column footing on a granite base. In the column there are a telephone and a closet for brooms, switch irons, etc., and from its base the various wires pass, through conduits, to their respective locations.

MECHANICAL INTERLOCKING.—The mechanical interlocking is the same in general principles as the standards in use in steam railway practice, except in one detail. In ordinary signaling a different signal is given for a clear track at each direction at any switch. In this equipment, on the other hand, at each of the switches a green light is thrown for "proceed" regardless of the direction in which the switch is thrown, but the direction of the switch must govern the interlocking of its signal with the other signals. To accomplish this, bars Nos. 1, 3 and 5 are provided with the swinging latches shown in Fig. 5, which care for the different signaling when the switches are reversed.

We will assume that each switch is normal for a right-hand turning and reversed for a left-hand turning. It will be remembered that the signals are normal and closed at red and reversed and open at green. Bars Nos. 1, 3 and 5 are for the switches and in this system do not control the interlocking of any but their own signals, but are themselves controlled by the signal bars Nos. 2, 4, 6 and 7. Take bar No. 2 as an example. In its reversed position, that is, when signal "2" is at green, this bar locks bar No. 1 in both its normal and reversed positions, locks bar No. 6 when bar No. 5 is in reverse, and locks bars No. 4 and No. 7 when bar No. 1 is reversed. When bar No. 5 is normal the swinging latch drops and unlocks bar No. 6, and when bar No. 1 is normal its swinging latch unlocks bars No. 4 and No. 7. Translating these movements to the track, they mean that signal "2" at green locks switch "1" in whichever position it has been thrown, locks signal "6" at red when switch "5" is to the left, and locks signals "4" and "7" at red when switch "1" is to the left. Thus it will be seen that the setting of signal "2" to allow the passage of a car prevents the setting of any signal for a car on a track which might bring about a collision.

The following interlocks hold:

"2" reversed, locks	"1" normal and reversed "6" when "5" is reversed "4" when "1" is reversed "7" when "1" is reversed
"4" reversed, locks	"3" normal and reversed "2" when "1" is reversed "6" when "3" is reversed "7"
"6" reversed, locks	"5" normal and reversed "2" when "5" is reversed "4" when "3" is reversed "7"
"7" reversed, locks	"2" when "1" is reversed "6" "4"

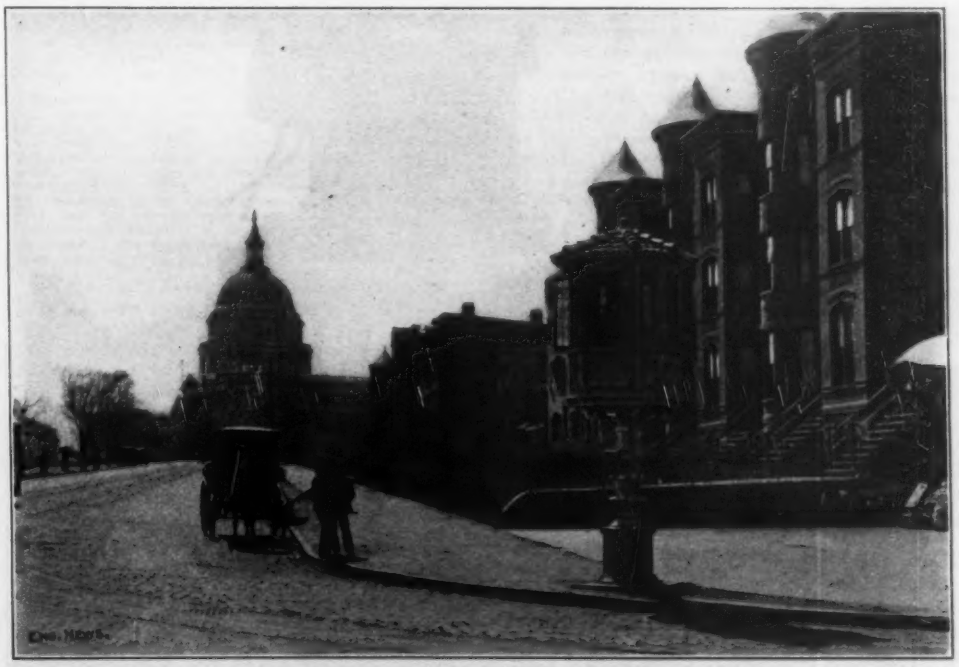


FIG. 6. SIGNAL TOWER FOR STREET RAILWAY CROSSING. LOOKING TOWARD U. S. CAPITOL, WASHINGTON, D. C.

These interlocks, it will be found, completely control the crossing, so that no two cars can take conflicting routes, providing that the motorman regards his signal.

The electric control is shown in Fig. 2. Current is supplied direct from the conductor rail circuit operating the cars and the resistance coils shown are interposed between the main line and each separate circuit. Cut-off is provided just outside of the resistance coils so that in case of trouble the whole signaling system can be thrown out and manual operation resorted to. The signals and their indicator lights normally carry current through the red, but moving the push-button shifts the current to the green lamp. The switch circuit is normally broken and the closing of it by the control lever actuates the solenoid at the switch, the movement of which closes circuit simultaneously on the indicator board model switches and on the return indication magnets. Two of the latter are provided, for the normal and for the reversed position of the switch, respectively.

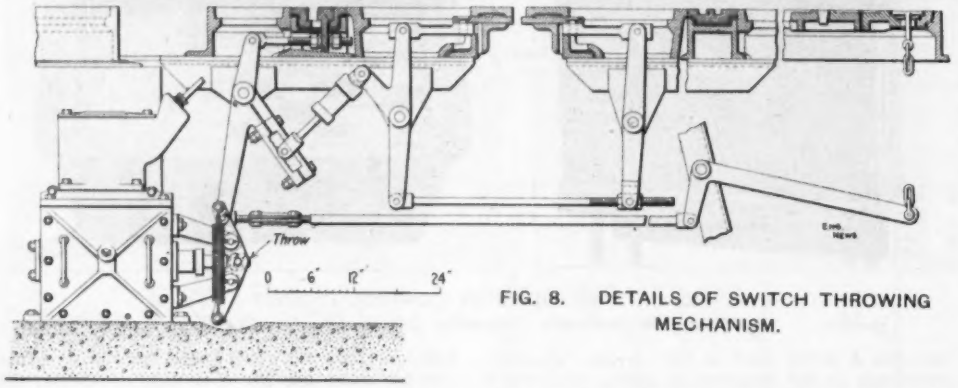


FIG. 8. DETAILS OF SWITCH THROWING MECHANISM.

Previous to the installation at this crossing, three men for switching and one man for signaling were employed there, doing work for which the one towerman now is sufficient. Thus for the two necessary shifts, there is the saving of the wages of six men at this one crossing. For the five crossings the saving in wages makes the mechanical system here described more economical in the long run.

ENGINEERING.—The entire track work incident to the new Union Station was carried out for the Capital Traction Co. and the Anacostia & Potomac River R. R. Co. by a joint board composed of Mr. D. S. Carll, 2d Vice-President and General Manager, and Mr. J. H. Hanna, Chief Engineer of the C. T. Co., and Mr. H. W. Fuller, General Manager, and Mr. C. S. Kimball, Engineer of Maintenance-of-Way of the A. & P. R. R. R. Mr. William B. Upton was the Engineer for the Board. The signaling system was built by the American Automatic Switch Co., of New York, and is the design of its Chief Engineer, Mr. Roy V. Collins. The towers were designed by Mr. Arthur B. Heaton and built by Mr. James L. Parsons. We are indebted to Mr. Collins and Mr. Upton for the information and illustrations herewith presented.

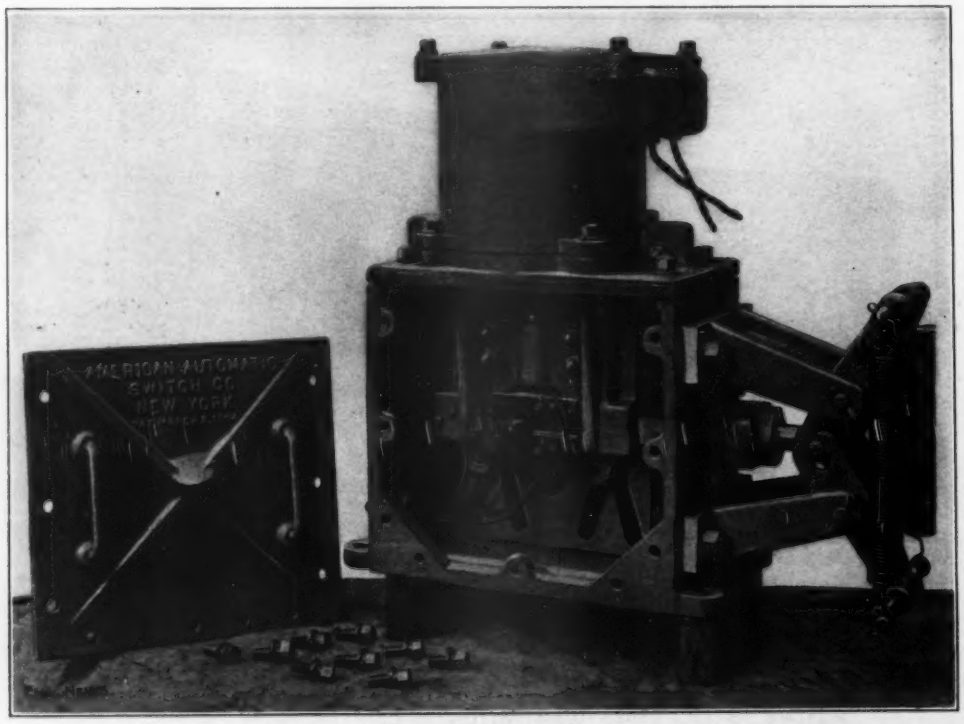


FIG. 7. VIEW OF CAM-PLATE BOX WHICH ACTUATES SWITCH THROWING MECHANISM.

Proposed Examination and Licensing of Civil Engineers in Pennsylvania.

The examination and licensing of civil engineers is proposed by a bill now before the Pennsylvania Legislature. The preamble to the bill is so interesting that we quote it, as follows:

Whereas, From time immemorial the profession of civil engineering has been regarded as an exact science demanding the highest type of mathematical and scientific culture, and

Whereas, The State should encourage and maintain high standards in every profession pursued by her citizens wherein judgment, ability, discretion and learning are prime essentials, therefore . . .

The plan proposed is to have a Board of Examiners of Civil Engineers, acting under the general direction of a Civil Engineering Council. The Council would consist of the Lieutenant-Governor, the State Commissioner of Highways and the State Superintendent of Public Instruction. The Council would hear appeals from the decisions of the Board of Examiners, and also, sad to contemplate, charges against the probity of any member thereof. The Council would also pass finally upon all examination papers, sign all licenses jointly with the Examiners, and (again sad to contemplate)

prefer charges for dismissal for incompetency, failure to perform duty, or dishonesty, against any member of the Board of Examiners for Civil Engineers to the Governor of the Commonwealth.

The Council would meet at least twice a year and always after an examination. Its members would "receive as compensation for services rendered $100." The examining board would be appointed by the Governor for terms of five years. The act requires that they be "recognized civil engineers" in actual professional practice for at least seven years, or professors of civil engineering in any properly constituted college or university in the state having power to grant the degree of civil engineering.

Applicants for licenses as civil engineers would make written application to the Examiners on or before April 1 and Oct. 1. The application would include the professional record of the applicant, "together with a brief history of any engineering work of importance upon which he has or has had supervision or was detailed." Examination would be conducted in writing, and the examining board would certify its conclusions and all the papers, with its recommendations, to the Civil Engineering Council. Applications for licenses would be accompanied by certified checks for $20, and a fee of $2 would be charged for the licenses themselves when issued. The funds thus arising would be used to pay the expenses of the examination. Any surplus would be equally divided among the Examiners, provided that none of them receive over $500 per year.

The act would not apply to civil engineers bearing diplomas or certificates of proficiency from recognized engineering schools of the United States or other countries; nor would they apply to any person who had practiced civil engineering in Pennsylvania for seven consecutive years, nor to mining engineers engaged in making surface surveys in connection with mine work. An ambiguity occurs in the act at this point, in that it provides that

all persons classed under the latter provision shall give positive proof of their right to practice the profession of civil engineering, and after due proof shall be awarded a regular license upon the payment of a fee of $10 to the treasurer of the State Board of Examiners.

It is not clear whether this means that mining engineers only, or both mining engineers and civil engineers of seven years' practice in the State, would have to supply the proof and pay the $10 license fee. A fine is provided for persons practicing civil engineering within the State who do not file with a county prothonotary the proof just mentioned by Jan. 1, 1910.

"Civil engineer" and "civil engineering" are defined in the act as follows:

The term "civil engineer" as applied and used in this act shall mean any person skilled in the principles and practice of any department of engineering, including surveying and profiling, and the words "civil engineering" as employed in this act shall be interpreted to mean that branch of engineering which relates to the construction or care of roads, bridges, railroads, canals, aqueducts, harbors, drainage and sewage works.

THE SURFACE RETARDATION IN OPEN CHANnels, or, in other words, the phenomenon that the filament of maximum velocity in a stream is some distance below the surface, is explained by a simple hypothesis advanced by A. H. Gibson in a paper read before the Royal Society Jan. 14, 1909 ("On the Depression of the Filament of Maximum Velocity in a Stream Flowing Through an Open Channel"). The frictional retardation due to sides and bottom tends to set up eddying movements in the water, the plane of the eddies being inclined inward toward the surface of the water. The tendency toward this eddying flow, combined with the free flow along the stream, produces a surface current setting from the sides toward the center of the stream, and correspondingly an outward bottom current. These currents carry the slower-moving water which was in contact with bottom and sides, and was retarded by their friction, toward the surface at midstream, and retard the velocity of downstream flow here. Near the middle the currents set downward, receiving accelerated downstream velocity, and finally flow outward again near the bottom. Their retarding effect makes the velocity near the surface less than the ideal velocity of flow, whereas at some depth below the surface they have a lesser retarding effect. Mr. Gibson has demonstrated the existence of the cross currents by observations in a test flume, in a river channel and in a narrow earth canal.

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The Pennsylvania House of Representatives has passed the bill promoted by Gov. Stuart to construct a highway across the State from Philadelphia to Pittsburg and thence to the Ohio line, and has appropriated $3,000,000 to be available within the next two years for construction of the road. The total cost for construction alone will probably reach $5,000,000; and, judging by the past history of state enterprises in Pennsylvania, it would not be safe to set a limit to the total outlay from the state treasury.

While various claims and arguments were made to secure the passage of the bill, it is perfectly clear that its real purpose and only justification is for the use of automobile tourists. Everyone knows that horse-drawn vehicles are wholly obsolete as competitors of the railway for traffic over long distances and that whatever merits the future freight automobile wagon may possess for short distance hauling, it cannot begin to compete with the railway over long distances. Evidently, then, if the new highway is to carry traffic enough to justify its construction, it must be a traffic of passenger automobiles, or in other words of pleasure tourists.

It is safe to say that if the scheme had been presented in this way to the citizens, or even to the legislature, it would have been turned down by an overwhelming vote. It is hardly conceivable that the taxpayers of the state would voluntarily take $5,000,000 from their pockets for the benefit of automobile tourists. The approval of the taxpayers or of their representatives would have been still less likely had they appreciated the heavy repair bills which will be necessary on such a highway subjected to a traffic of high-speed automobiles. As we write, a newspaper item is before us stating that the New York State treasury is to be called on for a million and a half dollars this season to repair the damage done to the new state roads by automobiles.

The point we would emphasize is that if money is to be spent by a state on the construction of improved highways, it should be spent where it will be of the greatest public benefit. It is now definitely known from actual traffic statistics that the roads on which improvement is best justified are the main highways radiating from the principal cities. Connections between these radiating roads to form through highways are well enough where and when they can be afforded; but they are the least important work for road improvement. To begin state highway improvement work by constructing through roads, such as that proposed in Pennsylvania is to begin at the wrong end.

If the Pennsylvania authorities really desire to promote the public welfare by good road construction, they should abandon their scheme for a through east and west road, which will benefit chiefly the wealthier class of automobile owners and devote the money instead to building radiating highways stretching out from the chief cities in all parts of the state. By a proper system of cooperation between the state and the counties, by which the latter would bear part of the cost, the $5,000,000 to be spent by the state on the new state highway could be doubled in amount and made to cover a very respectable mileage of improved roads, so located that all parts of the state would receive direct benefit.

Some of our readers may recall the exploit in "High Finance" in connection with New York street railway matters which was revealed in October, 1907.* An investigation by the Public Service Commission showed that some $715,000, which appeared on the books to have been paid for the purchase of the franchise of a "paper" railroad, had really been distributed to Wm. C. Whitney, Geo. W. Elkins, Thos. F. Ryan, Thos. Dolan and P. A. B. Widener. The transaction had been covered up by making the payment through a third party, Mr. A. N. Brady.

Following this revelation the matter was taken up by District Attorney Jerome and is said to have been brought before the Grand Jury, but no indictments were found. Proceedings in the civil courts to recover the amounts thus paid were undertaken, however, and on March 25 this litigation was settled by the payment to the Metropolitan Securities Co. of $692,292.82 by the counsel representing the last three men above named and the attorneys representing the estates of Whitney and Elkins, deceased. In making this payment a letter was made public in which the following explanation is given of the payments made to these five men in 1902.

> Upon full investigation, it has been established that in 1900 W. C. Whitney arranged certain advances to the Metropolitan Street Railway with the understanding that they should be repaid. Such advances were made by himself and by Messrs. Elkins, Dolan, Ryan and Widener. Some two years later, each of these was reimbursed the exact amount advanced by him, with interest. This reimbursement was effected by the Metropolitan Securities Co. at the time of its purchase of the securities of the Wall & Cortlandt Street Ferries Railway Co.
>
> None of the gentlemen named made any profit whatever out of the transaction. Each received the exact amount advanced by him, with interest, and no more.
>
> * * * * * * *
>
> While it is clear, after a full examination of the facts, that the moneys of the Securities Co. were used to repay advances made to the Street Railway Co., our clients have been advised that the Securities Co. may be entitled to follow these moneys, notwithstanding the indebtedness of the Street Railway Co. to them. They have therefore, determined to return to the Securities Co. the exact amount received by them, respectively, reserving, however, and not surrendering their right to repayment by the Street Railway Co. of the advances made by them for its benefit. We accordingly enclose herewith a check to your order for $692,292.82 in settlement of this litigation.

As the New York "Journal of Commerce" remarks, "This explanation does not wipe out the scandal or explain what that money really went for." If it was necessary to borrow money for the Metropolitan Street Railway treasury in 1900, why was not the borrowing done in the usual business fashion? Was there some "yellow dog" to be purchased or paid for, which would not make an ornamental showing on the company's books? If the transaction was a proper one, why the attempt to cover up the final restitution through a transaction with a third party? The public is justly suspicious of such transactions.

It is not wholly without interest in this connection to refer to the investigation now going on at Chicago into the expenses of the street railway companies. Former Mayor Dunne has publicly charged that at least $600,000 was paid by the street railway companies to "slush" and "educational" funds which were used to secure the passage of ordinances settling the relations between the city and the companies. Mr. Dunne is quoted as saying:

> The city is not receiving its rightful dues from the traction companies. When the ordinances were up for passage I held that the city should get 8% of the gross receipts. When we fought for this percentage the "slush" fund was turned loose. It did its work. The ordinances were passed.
>
> On reliable information I say that the traction companies spent $600,000 in putting through the ordinances. It was spent in various ways. Two prominent politicians, I am informed, received $50,000 each. The remainder was dished out to the smaller fry.

The investigation shows that two New York lawyers, Geo. W. Wickersham (now Attorney-General of the United States) and Louis C. Krauthoff each received a fee of $200,000 in connection with the work of securing the settlement with the city and the passage of the ordinances.

Since under the arrangement between the City of Chicago and its street railway companies, the city is entitled to a percentage of the company's earnings, any undue or unwarranted expenditures by the street railways are a matter of direct interest to the public as well as to the holders of street railway securities.

Stimulated alike by the conservation spirit of the day, the successful example of foreign cities and the inherent merits of the proposition, the American Civic Association has launched a movement for municipal forests. This it has done by preparing a bill and securing its introduction in the Pennsylvania Legislature. The Association proposes to extend its efforts to other states.

In the preamble to the Pennsylvania bill it is stated that experience has shown that municipal forests in Continental Europe have proved themselves to be important sources of revenue. It is also stated that many townships, boroughs and cities of Pennsylvania are so situated that municipal forests would conserve and protect their water-supply, promote the healthfulness of the municipality, and be a means of reducing taxation. The act then proceeds to authorize cities, boroughs and townships of the first class to acquire, by purchase, gift or lease, either forested areas or areas suitable for forestry. Such lands may be either within or outside of the municipal areas. Funds to pay for the lands so acquired may be derived either from current revenue or from bond issues.

Before any land is purchased under the proposed Pennsylvania law, the approval of the land selected must be secured from the State Commissioner of Forestry. After the land has been acquired the Commissioner would be notified, whereupon it would be his duty to make rules for the government and administration of the forestry areas. Such rules would be published by the municipality, and it would be compulsory upon the municipality to follow them in its administration of the forestry areas. The act provides that municipal forests might be used for general outing and recreation purposes, subject to established rules "in which the major idea shall be the sale of forest products for producing a continuing municipal revenue."

The original draft of the act authorized condemnation proceedings for the acquisition of forestry areas, but this provision was eliminated after the bill was introduced in the Pennsylvania Legislature.

By way of furthering this municipal forestry movement, the American Civic Association has issued a statement in the course of which it says:

> The extent to which Germany has recognized the value of its forests is illustrated by the fact that in the single province of Baden, of its 1,564 communities, 1,350 own their own forests and in addition 287 corporations, such as schools, churches and hospitals, possess forest lands. From an aggregate of 1,342,944 acres these communities and corporations are allowed to cut yearly 261,724 M. ft. B. M. of timber and wood, with a net value of about $3,600,000. The city of Baden alone owns 10,576 acres, from which it has derived a net income of $66,079.68 or $6.25 per acre, all of which goes to the general fund for the maintenance of the municipality.

It adds that Berlin is now proposing to expend $10,000,000 in the acquirement of forests.

We may note that Massachusetts, which has led in so many good movements, has already on its statute books a law providing for forestry work by townships which is in some respects like

*See Engineering News, Oct. 17, 1907, p. 413.

the proposed Pennsylvania act. We do not remember whether cities in Massachusetts are enabled to acquire forests outside their boundaries, but as to this it may be noted that, numerous as are places of considerable size in Massachusetts, there are only about 35 incorporated cities; so that forestry legislation applicable to townships would affect nearly the whole state.

The general movement now being furthered by the American Civic Association is a commendable one. Nearly all of the vast amount of forestry work which ought to be entered upon at once in this country is quite beyond the economic possibilities of individual effort. But it is well within the field of both municipal and private corporate endeavor. Six years ago we outlined the forestry work already in hand on the water-works drainage areas of the Metropolitan Water and Sewerage Board (Boston and vicinity), Woonsocket, R. I., Hartford, Middletown and New Haven, Conn., and Johnstown, Pa. (the last two works are privately owned), and several Western cities. Doubtless this has been considerably extended since that time, and it seems bound to have great impetus in the near future.

The incline-railway accident at Pittsburg, last week, is said to have been the only accident of the sort that Pittsburg has experienced in many years, in spite of the large number of inclines which climb the bluffs bordering the Monongahela and the Allegheny banks. But such long-continued freedom from accident should not blind one to the lack of safeguards on most of these inclines. We understand that few if any of these inclines have any automatic safeguards against overwinding. Practice has long ago recognized the vital need of automatic stops, in inclines as well as in vertical shaft hoists. The accident at the South 22d St. incline was caused by overwinding, and it clearly confirms the need of provision against such accidents.

The essential requisites of automatic stops (or whatever other name we may give to provisions against overwinding) are fairly well known. Numerous modern inclines, both rail and cable, as well as the multitude of elevators and mine hoists, furnish models therefor. But question may be raised as to another feature, namely, protection against disaster in case the hoisting cable breaks or pulls out.

Passenger elevator practice has reached the point where emergency brakes on the car are regarded as essential. Repeated elevator accidents, always of serious nature, have demonstrated that exclusive reliance on the cables is not adequate. The principle has been adopted also for some inclines, most recently in the case of a notable cable incline on the slope of the Wetterhorn, in Switzerland. In fact, is not a steep incline railway closely analogous to the vertical hoist, in relation to its conditions of safety? Either of them, if the cables give way, is practically certain to produce a fatal wreck. It is not easy to see a sound reason for making a dividing line between a vertical hoist and a 1:1 incline, such that a car brake should be essential on one side of the line and not on the other.

There is a new conflict on in San Francisco between the advocates of cheap building and the advocates of safe building. Some of the real estate owners find the present prohibition of wood construction in downtown districts very irksome, and they have appealed to the Board of Supervisors to modify the requirements. They want permission to erect wooden buildings sheathed with a non-combustible covering—in other words, brick veneered buildings, a type of structure which experience has shown to deserve severest condemnation since it offers little more resistance to the spread of a conflagration than on ordinary wooden structure. As usual, the argument for cheap buildings is supported by numbers, and by the plea of "helping business."

As usual, also, the number who appear in defence of the public interests and the public safety is relatively few, among them, however, were Fire Chief Shaughnessy and Mr. J. D. Galloway, M. Am. Soc. C. E. (of the Advisory Committee on Building Laws).

In this case, as in many similar ones, a small minority may be a wiser and better guide than an overwhelming majority. The lessons of the fire of 1906 have already been too much disregarded in San Francisco. To erect brick veneered buildings in a region subject to earth tremors would seem to be the climax of reckless stupidity.

State and Local Health Administration in North Carolina, Ontario and Great Britain.

The financial support given to many state and local boards of health is so very inadequate as to make it a matter of surprise that they are able to do any effective work whatever. This is particularly true where the population is sparse and largely rural. A notable instance of meager appropriations for state health board work, has been brought to our attention by the January bulletin of the North Carolina Board of Health, and some unfortunate rural conditions in Ontario have also come before us, as noted farther on. We append a few notes on the unsatisfactory condition of local health administration in a number of the smaller cities, towns and rural districts of Great Britain.

Created in 1877, the North Carolina Board of Health had at the outset no appropriation whatever from the state; later on, $200 was made available, still leaving the Secretary of the Board out of pocket for money used for postage and the like. Some 20 years ago the appropriation for the board was raised to $2,000, with a provision for meeting the cost of printing and stationery outside of that sum. For a round score of years this appropriation has remained unchanged in amount, and that for a state which had a population of 1,893,810 in 1900. It should be noted that the health-protective work of the state is not limited to the $2,000 named, for $3,000 is collected by the state as "water tax, to support the Laboratory of Hygiene, and $5,000 for the support of the Sanatorium for Tuberculosis." In 1893 the salary of the secretary of the board was fixed at $1,000 a year. Commenting on this the bulletin says:

> Of this amount he has paid an assistant $250 to do the statistical work, for which he had no time. His net income from this source being, therefore, only $750, he has had to make his living by the practice of medicine, and, consequently, the health work of the state has necessarily been a side issue and a secondary matter.

The bulletin suggests that provision should be made for a secretary who would devote his whole time to the work of the Board, and that in addition a competent assistant should be provided to look after office work while the secretary is absent and to have charge of vital statistics.

The statements are also made that "a first-class stenographer is a prime necessity," and that a special assistant is needed for tuberculosis work. The modest sum of $10,000 a year is suggested as needed for carrying on effectually the work of the State Board of Health, but it is pointed out that South Carolina gives its Board $12,000 a year, besides a provisional appropriation of $5,000 at the discretion of the Governor, that Georgia gives its Board $16,000 a year and Virginia $40,000.

It is distressing to any one who has any appreciation of what is needed in the way of health-protective work, particularly in the South, to think of this meager North Carolina appropriation and of the secretary of the Board struggling on year after year, attempting to meet the problems which confront him, without any trained assistant and without even a stenographer. However conscientious a man may be, he cannot serve two masters effectually, especially when one of them is himself; or, in other words, it is not to be expected that a man can make a living through the practice of medicine and at the same time do all that is needed as secretary of a state board of health. As the bulletin says, under such conditions health work is necessarily "a side issue and a secondary matter."

Aside from the time element, it matters less if a state health official is compelled to practice medicine in order to earn a living, t[illegible] if this is necessary for the health officer of a [illegible]icipality. That is to say, the private and profes[illegible]al interests do not clash with duties to the p[illegible]lic nearly so much in the case of the state as [illegible] the local health officer, since the practice of t[illegible]state official is necessarily limited to a small [illegible]rt of the territory for which he is responsible, [illegible]hile with the local official the professional and [illegible]ministrative areas are generally identical.

The unfortunate condition of affa[illegible] that is likely to prevail wherever a practicing physician serves also as a local health officer is strikingly pointed out in an article in the Novem[illegible]r number of the quarterly known as the "American Journal of Public Hygiene." The article is entitled "The Rural Health Officer," and was written by Dr. Charles A. Hodgetts, Chief Health Officer of Ontario. After commenting on the conflict between professional and official duties, and the inadequacy of compensation for health officers in rural districts, Dr. Hodgetts says further:

> I am not certain but the general practitioner is not foolish in accepting the appointment, for certainly in my experience the acceptance of the office is suicidal to his best professional interests. Particularly is this the case when with the appointment, which in Ontario is by either by-law or resolution of the township, village or town council, his annual remuneration is set down at the miserable pittance of $25, or even less.
>
> How often in a case of this kind has the well-meaning municipal health officer found that long before the expiration of the twelve months he has brought down upon his well-meaning head the displeasure of council, local board and many of his former patients. He has brought no grist to his professional mill and received literally "the chaff" instead of the "flour" which means life to himself and family.

Any one who has intelligently observed the work of many local boards of health, where this work is in charge of physicians in private practice, will agree that Dr. Hodgetts has not overdrawn his picture at all; we may add that the picture is often, if not generally, just as correct a portrayal of the facts in the case of city as of rural conditions.

The remedy suggested by Dr. Hodgetts for rural districts is to put "a number of townships, villages, and possibly a few towns" under the direction of a single competent and well-paid health officer, whose appointment would be subject to the approval of "a central provincial or state authority," and whose "dismissal should only be for cause." Such a man would devote his whole time to his official duties. Moreover, he would be provided with proper laboratory facilities, which is a rare thing, outside of cities, in either Canada or the United States.

This suggestion, while good so far as it goes, raises some troublesome points. The first is that there is not, in the United States at least—and we are pretty sure there is not in Canada, either—any adequate means of training health officers. A second point for discussion is whether, in view of all the facts, it is not high time to get away from the notion that executive health officers should be physicians. With the changed ideas of recent years as to what health-protective work should be, it has become more and more evident that medical training gives men very little indeed of what is needed of a health officer, compared with the theory and practice which falls to the lot of the well-trained and efficient sanitary engineer.

There may be reasons why, for health officers of such consolidated districts as Dr. Hodgetts suggests, the selection should be from men of medical training, especially if high-grade men were chosen. The chief of these reasons is perhaps that in rural districts there is more need than in urban sections for supplementing the knowledge and training of local physicians by the presumably superior qualifications of the sort of medical health officer who should be chosen for such a position. In the larger towns and all of the cities of importance, this need does not exist, or, in so far as it does exist, it may be met in other and better ways. As a rule, the physicians in urban districts are likely to be better trained, to keep more fully abreast of advances in their profession, and to be broader-gaged generally in matters of public policy, than is the case with country doctors. There is, therefore, less need for what may be termed medical supervision in the public interests in the city than in the country. Moreover, when a city health board or

health officer does need to pass upon questions involving medical knowledge—such, for instance, as the diagnosis or proper isolation and disinfection in the case of infectious diseases—that board or officer will find no difficulty in securing medical specialists for the purpose. In the country, such specialists are not always easily secured, particularly men who are well posted in modern methods of controlling the spread of disease from person to person.

There is an argument for choosing sanitary engineers rather than doctors for health officers that should not be overlooked; the engineer could fill some other public office more readily and efficiently than could the doctor. A combination of two public offices in one man is far different from having the incumbent of each piecing out his income by professional or other private work—the health officer practicing medicine and the town engineer doing what surveying he can pick up. It is true that, where professional or technical training is involved, greater efficiency might be expected if the municipal officer served two or more small communities in his specialty, instead of trying to follow two specialties in one community. Of course there might be decided advantages in having a municipal official fill two different offices in a single community, and thus always be at hand ready for service, rather than having him render the same class of service for two towns and always liable to be in one when the other needed him most. The choice might almost be left to the chances of a toss-up; or better, to local preferences and exigencies.

Pending the establishment of numerous well-designed and equipped schools for training health officers, there is very much to be said in favor of choosing such men from the graduates of our best technical schools, where sanitary engineering, chemistry and biology are taught, rather than in taking them from the medical profession. The men from the engineering schools, if possessed of the executive ability necessary to any successful health officer, can readily call to their aid the best medical knowledge and experience of their respective communities whenever any emergency arises. In case of those all-too-common political exigencies which turn the most efficient of health officers out, perhaps the engineer can more readily resume the practice of his profession than can the doctor. That is, he is more in touch with his own line of professional work and can more readily reestablish a clientage than can the medical man who has dropped his practice entirely for a series of years.

Finally, regardless of what every one may think as to whether the health officer should be chosen from the engineering or the medical profession, there can be no doubt but that the efficient health officer, whether state or municipal and whether urban or rural, should devote his whole time and energy to the work and be adequately paid for the invaluable services which are so much needed to conserve to the utmost the public health.

That the foregoing observations do not apply to the United States and Canada, alone, is shown by some strong evidence which has come to hand since they were put in type. This we have found in the report of the Medical Officer of the Local Government Board of Great Britain, for the year 1906-7. The report, among other things, contains many condensed abstracts of reports by medical inspectors on local investigations carried out by them during the year. These reports indicate that British municipal health administration, in communities and districts of say 60,000 population downward, is in many instances in a very unsatisfactory condition. Various sanitary defects are pointed out which certainly could not exist under model municipal government in any country.

The very first report listed, dealing with the Aberayron Rural District in Cardiganshire (population 1901, 8,170) states that the inquiry was held because of

> persistence on the part of the Council in appointing two medical officers of health against the [Local Government] Board's recommendation to appoint only one for the whole district.

These two officers received the "grossly inadequate salaries of £20 per annum" each, and the inspector of nuisances received the "paltry salary of £30 per annum." Moreover, this inspector is described as "an aged man who is also master of the workhouse, and who has had no training in the duties of the former office."

Of another municipality, laboring under the name of Ashton-under-Lyne, and which had a population of 43,890 in 1901, the inspector states:

> For a town of this size a properly trained, experienced and qualified medical officer of health is required, prepared to devote most, if not all, of his time to his public health duties.

The sanitary inspector of Darlaston (population 1901, 15,395) is described as "old and incompetent," and it is urged that the district needs "a qualified sanitary inspector in full bodily vigor."

One of the most interesting states of affairs disclosed by the report relates to Trowbridge, in Wiltshire, which had a population of 11,526 in 1901. The investigation in this case was due to the fact that the Local Government Board was not

> satisfied with the explanation given relative to the new arrangements proposed for the discharge of the duties of inspector of nuisances.

Inquiry showed that the inspector of nuisances, who had been serving for several years at a salary of £80 per annum, had not been reappointed at the expiration of his term. The reason given was that the District Council had decided to consolidate the offices of assistant surveyor and inspector of nuisances at a salary of £100 per year (£20 and £80, respectively). The old inspector, in making complaint to the Local Government Board, stated:

> In the performance of my duties I have unfortunately come into conflict with the private interests of several members of the Council. This was unavoidable considering that there are on the Sanitary Committee three large house agents and two butchers. . . . I have been interfered with by individual members of the Council when carrying out the details of my duties.

The principal lesson to be drawn from these British reports, including the many from which we have not made citations, is the need for more liberal appropriations for health-administrative work, the employment of competent, well-paid, full-time health officers, and the fearless administration of the British Health Acts. The latter responsibility, as we understand it, rests largely upon the urban and rural district councils,* many of which refuse to back up their health officers and some of which lose no time in getting rid of health officers whom they consider to be over-strenuous in bringing prominent citizens to terms.

We desire to call particular attention to the importance which the Local Government Board inspectors attach to the employment of full-time health officers and to their repeated suggestions (not made evident by our meager extracts) for reuniting under one official the health administrative work of several districts, whenever one district alone cannot afford to give proper support to a competent man. This is what Dr. Hodgetts recommends for Ontario, as we have already stated. The joining of districts is already practiced to a considerable extent in Great Britain, we understand, but we fear the competency of the appointees is all-too-generally ignored.

British health law and practice appears to take it for granted that the leading executive health officer shall be a man who has had a medical training. Although appointments of most of these medical officers of health, as they are termed, are submitted to the Local Government Board for approval, evidence a plenty comes to our attention every year that British health-protective work would be greatly bettered if there was infused into its administration a greater measure of modern ideas on sanitation. Even the reports of the medical inspectors sent out by the local government boards show an apparent confusion of ideas as to the origin and spread of infectious diseases. At least this is a natural conclusion to draw from several lengthy reports made by inspectors who were sent out to learn why diphtheria, for instance, was so prevalent in certain localities. Instead of confining themselves to inquiries regarding antitoxin, isolation, disinfection and such general preventive means as medical inspection of school children, these reports on diphtheria investigations deal largely with aspects of local sanitation which have no relation whatever to diphtheria, except as affecting the general health of the district. Possibly it is the policy of the Board to make each visit to a district the occasion of a general inspection, regardless of the immediate cause of the visit. But the reports contain no intimation to that effect, and thus must be very misleading to district councilmen and citizens alike—if they are not, as we think it probable, to medical health officers and the medical profession generally.

While we believe that health administration as a whole is far better in Great Britain than in the United States or Canada, yet it is evident that Great Britain, as well as Canada and the United States, has serious health-administrative problems to solve. One of the greatest of these is how to ensure that local governing boards will appoint the best men available to health-work positions and then back up their appointees in every way in their power.

*We are not here discussing health administration in the larger towns and cities of Great Britain.

LETTERS TO THE EDITOR.

Unit Stresses for Timber.

Sir: Referring to your issue of March 25, the table of unit stresses for timber as quoted on p. 310, without the full notation recommended by the committee, gives an erroneous impression. The values given are, in reality, for either "green" or ordinary air-dried material for use in railway bridges in which there will presumably be impact stresses not otherwise provided for.

Further, as you state on p. 334, these units may be increased by 25% for highway bridges and 50% for buildings or where the timber is protected from the weather and not subject to impact.

In addition the value of the modulus of elasticity is to be reduced one-half in computing the deflection for a load applied for a long time.

As these unit stresses will in all likelihood be widely used, it is important that the explanatory notes presented to the convention, but not originally attached to the table, be given equal prominence.

Yours truly, R. D. Coombs.

1123 Broadway, New York, N. Y., March 28, 1909.

The Necessity for Drainage Under Concrete Sidewalks.

Sir: After reading the interesting article on "Failures in Concrete Sidewalks" in your issue of April 1, p. 342, and the "Standard Specifications" following, a word of comment seems apropos.

The most casual perusal of the article makes it manifest that the continued integrity of such pavements in our northern climate depends principally upon sufficient drainage. The article itself treats of this condition fairly well, although more emphasis should be put upon it. But the specifications, which are supposed to dictate the correct practice, are entirely silent in the text. A little practical experience will illustrate the point and show the great importance of a strong specification. In laying the tar concrete sidewalk on the streets of this place, where the material is a hard clay which heaves to an extraordinary extent in the winter, several owners took the precaution to dig out the clay to a depth of 12 to 16 ins. or more, and replace it by gravel or furnace clinkers or both, *but without making provision for draining away the water which might get into the excavation.* Consequently, such pavement, in the course of two or three seasons, has been badly contorted and broken, and left with ups and downs as though twisted by an earthquake. Evidently this was due entirely to the water collected in the trench, which could not drain away but soaked the surrounding clay and greatly aggravated its natural bad qualities. I would, therefore, include in the "Standard Specifications" a very emphatic paragraph requiring a sub-grade arranged for drainage, and preferably the use of inexpensive agricultural tile which would provide free passage of water along the lowest line of the sub-grade.

Tar concrete pavements, at least when laid upon the surface of ordinary soil with good bedding of cinders or gravel, will keep their shape remarkably well by being free to the uniform up and down action of the frost throughout their whole extent; and concrete slabs should do equally well.

It seems to the writer a great mistake to lay concrete sidewalks without some metal reinforcement. The

expense of some suitable, cheap, wire mesh is inconsiderable, with the certainty of resisting the effects of ordinary expansion and contraction. This should also be properly expressed in a specification.

Yours very truly,
Robert Fletcher.

Hanover, N. H., April 5, 1909.

Discharge Formulas for Cast-Iron Pipe.

Sir: The "simple and easily remembered pipe-discharge formula" given by Mr. C. C. Vermeule in your issue of Jan. 21, 1909, led the writer to compare it with a so-called rough formula which he had been using, and later to make a fuller comparison with various standard formulas. The accompanying table resulted:

Twelve formulas were calculated for slopes of 2 ft. to 5 ft. per 1,000 ft. and for diameters of 4 ins. to 30 ins. Of these only three give concordant results, namely, those lettered (*c*), (*h*) and (*o*). Taking the formula (*c*) as a standard, the other two compare extremely well with it. An approximate agreement with these is found also in the two simple or rough formulas (*a*) and (*b*). The former is, for 4-ins. diameter, 3% too low (which is close enough), and for 30 ins., 12% too low (not close enough), the variation increasing with the size of the pipe. Formula (*b*) is recommended for pipes from 6 ins. diameter up, the discharge being about 4% in excess for 6 ins. to about 2% too low for 60 ins. with a slope of 5 in 1,000 (an extreme slope, giving about three times the economical velocity for 60-in. pipe).

Formulas (*c*), (*h*), (*o*) and (*b*) apply to long, clean cast-iron pipes as ordinarily used for water supply and distribution systems. The carrying capacity of old pipes would be determined by the usual method of friction factors for age of pipe as published in hydraulic works.

George L. Bean.

1729 N 19th St., Philadelphia, Pa., Jan. 29, 1909.

Sympathy for the Young Engineer and His Troubles.

Sir: Realizing that "Three Year Old," in the letter printed in your issue of March 4, along with a vast number of cub engineers would appreciate a few words of sympathy from one who has passed through just such experiences as they are now enduring, with your kind permission I would extend it to them.

The complaint of under-pay is as a rule not well founded and the compensation is as adequate as can be expected when introducing a new and untried article to the trade. The completion of a four-year (±) course of study and the granting of a degree by the Faculty and Board of Trustees, is but the start of the apprenticeship leading up to the degree of Master of his Art; and all young engineers will learn, as the writer did, that college training gives but the mental tools with which to build the completed structure of an engineer.

A bit of personal experience as related by one now standing well up in his profession might illustrate the point of the true value of the cub engineer. He was a graduate C. E. from one of the leading institutions. He was sent to take a position on a locating party on railroad work in the Rockies. He came in a Pullman to the nearest station with the full limit of baggage checked and in his berth, consisting of steamer trunks, suitcases and hat boxes, with a letter from the president of the road (who happened to be a personal friend of his father), a diploma with the ink barely dry, and loaded fully 200% beyond his rated capacity with the idea of his own importance and ability. The hat boxes and steamer trunks were unceremoniously discarded at the foot of the trail, not without many indignant protests from the Cub and vigorous and emphatic English from the mule skinners, who transferred some of the contents to a gunnysack. The balance of the cargo ascended the 20% trail not diminished in the least, vowing summary dismissal for mule skinners who in such a rude manner made him discard a portion of his equipment.

Fully resolved to lay his letter, diploma and grievances before the chief of party, when he arrived at the group of tents he made a search straightway for that individual. There was only one man with a white collar, which, according to the cub's training, was a sure indication of superior rank. He presented his letters without further ado; imagine his disgust when the white-collared man, looking them over with a laugh, said: "Sonny, the ole man is out on the line up the gulch. I am only the Flunky. You'll have to see him. I reckon he'll be in before dark." And when he did come in, as in all locating parties, they all looked alike; there were no biled shirts, patent leathers, no derby hats, just a bunch of corduroy-and-overall-clad, unshaven men, who used plain English without any galvanizing or sandpaper finish, and in tones that would cover 100 yards in record time.

The old man was found. He never even opened the papers and the letter, but tossed them into his tent on his bunk and told the young hopeful to wash up, get in and find himself a place in the grub tent and fill up, throw his rags in one of the "bull pen" tents and he would talk to him afterwards. This was adding insult to injury, and to think of the Flunky relating his mistake to the merriment of the whole corps was past endurance if there had only been some way to escape.

After supper the last portion of the overloaded cargo was thrown overboard. The chief clapped his hand on his shoulder in a friendly way and told him how all-fired glad he was that he came. "Just had to send Bill down the trail because he fell over the bluff and was all bunged up," Sam the "pig tail" (back flag) was promoted to axeman, and he could go on in the morning in Sam's place. He could find a place in one of the tents called "bull pens" and turn in for the night.

It was all unloaded now and the shock was nearly all that he could bear: he who never flunked a term or an exam., who graduated with honors, whom even the class prophet could not bring to ridicule by a mock prophecy of future greatness. He forgot the hat boxes and steamer trunks in the shack at the foot of the trail. Lost in grief he pulled the blankets over his head to keep the mosquitos off and shut out the lusty snores of his tent mates and the occasional hee-haw of the camp's motive power, only to wake at the melodious sound of the drill-steel triangle which told that it was ten minutes to breakfast.

He took his place with the picket and b… the day was over he realized for the first time t… there was something to be learned besides what w… ritten in books and delivered in lectures or in the … fieldwork of a college course; that the despised job … tail was something that even Prof. De Biggers … ot know about; that even in the humblest position … the corps there was much that he had to learn. Th… man, the stakeman, the rear chainman, each and … uld give him pointers that even his learned profe… did not think of. Doing things and telling how … different. The transitman, the field draftsman, the … man who never even passed through college, loomed … men of action, looking beside his professors like … nts to a pigmy.

The writer himself has passed through … mill. He drove stakes for $1.25 per day; he reporte… and de- signed water-works for $1.50 per day, wh… those for whom he worked got $6.00 per day for h… abor; he was engineer in charge of important wo… involving many thousands of dollars—in charge in f… as well as name; he opened up and developed … meant thousands of dollars to his company, what … umbers of others tried to do and failed. It was wo… of love rather than for pecuniary gain, from 6 a. m. … twelve at night, and he received $75 per month for … But he

TABULAR COMPARISON OF VARIOUS PIPE-DISCHARGE FORMULAS. FOR CLEAN CAST-IRON PIPE. DISCHARGE IN UNITS OF 1,000,000 GALLONS PER 24 HOURS.

Formulas Tabulated:	Source:
(*a*) $Q = 0.05\ d^2\sqrt{d\,s}$	Vermeule, Engineering News, January 21, 1909.
(*b*) $Q = 0.001760\ d^2\sqrt{h\,d}$	
(*c*) $Q = 0.00354\ d^2\sqrt{\frac{h}{F}}$	Weston's tables, $v = \sqrt{\frac{h}{F}}$
(*d*) $Q = 0.00354\ d^2\sqrt{\frac{2\,g\,r\,i}{m}}$	Fanning, $v = \sqrt{\frac{2\,g\,r\,i}{m}}$
(*e*) $Q = 39.528\ D^{2.694}\ s^{0.555}$	Lampe, $q = 61\ D^{2.694}\left(\frac{H}{L}\right)^{0.555}$
(*f*) $Q = .30578\ d^{\frac{8}{3}}\ D^{\frac{1}{3}}\ S^{\frac{1}{2}}$	Flamant $v = 86.38\ D^{\frac{1}{3}}\ S^{\frac{1}{2}}$
(*g*) $Q_{.010} = 1.68\ Q_{.015}$	From Kutter's formula (and Swan & Horton)
(*h*) $Q = 0.00354\ d^2\ c\sqrt{RS}$	Darcy, $v = c\sqrt{RS}$
(*k*) $Q = 0.00354\ d^2\ (97.05\sqrt{RS} - .08)$	Prony, $v = 97.05\sqrt{RS} - .08$
(k_1) $Q = 0.00354\ d^2\ (99.88\sqrt{RS} - .154)$	" $v = 99.88\sqrt{RS} - .154$
(*m*) $Q = 0.00354\ d^2\ (108\sqrt{RS} - .13)$	Eytelwein, $v = 108\sqrt{RS} - .13$
(m_1) $Q = 0.177\ d^2\sqrt{\frac{D\,H}{L + 50\,D}}$	" $v = 50\sqrt{\frac{D\,H}{L + 50\,D}}$
(*n*) $Q = 0.16992\ d^2\sqrt{\frac{D\,H}{L + 54\,D}}$	Hawksley, $v = 48\sqrt{\frac{D\,H}{L + 54\,D}}$
(*o*) $Q = 0.00354\ d^2\ (140\sqrt{RS} - 11\sqrt[3]{RS})$	Neville, $v = 140\sqrt{RS} - 11\sqrt[3]{RS}$

The symbols have the following meaning:

v = velocity, feet per second.
Q = discharge, units of 1,000,000 gals. per 24 hrs.
q = discharge, cubic feet per second.
d = diameter of pipe, inches.
D = diameter of pipe, feet.
s = fall in unit length.
h = fall in ft. per 1,000 ft.
H = fall, total.
L = length, total.
S = sine of slope.
R = hydraulic radius, ft.
F = Weston's factors.
c = Darcy's constants, having values as follows:

d	4	6	8	10	12	16
F	1.161	.722	.522	.408	.335	.247
c	102	105	107	109	109.5	110.5

Fall, 2 ft. per 1,000.

	a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*h.*	*k.*	k_1.	*m.*	m_1.	*n.*	*o.*
4″	.071	.080	.074	.068	.083	.081	.065	.075	.067	.064	.071	.072	.070	.068
6″	.197	.220	.210	.196	.199	.244	.193	.206	.185	.181	.202	.198	.191	.195
8″	.404	.437	.442	.426	.436	.529	.435	.444	.385	.378	.420	.416	.390	.406
12″	1.115	1.245	1.240	1.240	1.300	1.600	1.360	1.250	1.070	1.060	1.170	1.110	1.070	1.160
24″	6.310	7.040	7.170	7.850	8.400	10.500	9.200	7.220	6.100	6.100	6.700	6.160	5.900	6.800
30″	11.000	12.300	12.560	13.800	15.400	19.200	16.900	12.600	10.700	10.700	11.750	10.600	10.200	12.000

Fall, 3 ft. per 1,000.

	a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*h.*	*k.*	k_1.	*m.*	m_1.	*n.*	*o.*
4″	.087	.097	.091	.085	.104	.104	.081	.091	.082	.080	.089	.089	.085	.096
6″	.242	.270	.258	.242	.250	.316	.236	.260	.230	.227	.251	.242	.234	.246
8″	.496	.536	.550	.526	.546	.684	.533	.543	.475	.471	.520	.498	.479	.514
12″	1.370	1.525	1.520	1.540	1.630	2.070	1.660	1.530	1.320	1.315	1.440	1.360	1.310	1.450
24″	7.740	8.620	8.770	9.660	10.500	13.600	10.300	8.850	7.500	7.600	8.300	7.540	7.200	8.550
30″	13.500	15.050	15.360	16.950	19.200	24.900	20.700	15.500	13.200	13.300	14.500	13.000	12.400	14.900

Fall, 4 ft. per 1,000.

	a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*h.*	*k.*	k_1.	*m.*	m_1.	*n.*	*o.*
4″	.101	.142	.104	.099	.122	.120	.093	.106	.096	.094	.105	.103	.099	.102
6″	.279	.311	.300	.282	.293	.363	.273	.300	.267	.265	.292	.280	.270	.289
8″	.572	.620	.624	.613	.641	.715	.615	.615	.552	.550	.605	.575	.552	.605
12″	1.580	1.760	1.752	1.790	1.910	2.380	1.920	1.780	1.520	1.520	1.680	1.570	1.510	1.700
24″	8.900	9.950	10.116	11.200	12.360	15.600	13.000	10.200	8.700	8.800	9.600	8.700	8.300	9.950
30″	15.600	17.400	17.750	19.600	22.500	28.700	24.000	17.900	15.200	15.400	16.800	15.000	14.300	17.500

Fall, 5 ft. per 1,000.

	a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*h.*	*k.*	k_1.	*m.*	m_1.	*n.*	*o.*
4″	.113	.126	.117	.111	.139	.136	.105	.118	.108	.106	.117	.114	.110	.115
6″	.312	.348	.335	.319	.332	.412	.305	.336	.299	.298	.328	.314	.302	.326
8″	.640	.692	.698	.692	.725	.893	.686	.702	.617	.618	.680	.644	.618	.682
12″	1.760	1.970	1.960	2.040	2.160	2.700	2.240	1.980	1.710	1.720	1.880	1.750	1.690	1.930
24″	10.000	11.100	11.320	12.600	14.000	17.700	14.500	11.400	9.800	9.800	10.750	9.800	9.300	11.200
30″	17.400	19.450	19.840	22.000	25.500	32.500	26.800	19.950	17.100	17.300	18.900	16.800	16.000	19.900
60″	....	109.8	113.5	....	....	....	....	114.0	....	....	....	....	....	115.5

was leaving the very things that could not be obtained in a college course. The opportunity was his to grasp. The more responsibility the more the opportunity, the more will he develop his mental powers and widen his grasp of affairs. His employers were taking the risks. Of course, he saw stokers, miners and timbermen receive more compensation, but they had reached their limit, while his only limit was that set by his own ability to grasp the opportunities afforded him.

Let the Year Old and other cub engineers bear in mind that while the mechanic has reached his limit, they have no limit. The opportunity, not the salary, should be the goal. Ever onward and upward will the competition be, till the thought of envying the mechanic's wage will appear ridiculous. To them all the older engineers should extend their sincere sympathy and encouragement.

Very truly, J. H. Eby.

Lancaster, Pa., April 3, 1909.

A Diagram for Bazin's Formula for Flow in Open Channels.

Sir: I forward with this a graphical solution of Bazin's formula for flow of water in open channels. It may be of some use to other engineers.

The Chezy formula is

$$V = c\sqrt{RS}$$

V = Velocity in feet per second.
R = Hydraulic radius in feet.
S = Slope in feet per foot.
and c = a coefficient.

Ganguillet and Kutter devised in 1869 or thereabouts a somewhat cumbersome formula to find c. According to their conception this value varies with the slope. Bazin differs on this point, stating that c does not vary with the slope but is constant with any slope, only varying thus:

$$c = \frac{87}{.522 + \frac{m}{\sqrt{R}}}$$

The numerator 87 is a constant in both metric and English systems, while .552 is a constant in only the English, its value being unity in the metric system.

Placing this value of c derived by Bazin in Chezy's formula we have:

$$V = \frac{87\sqrt{RS}}{.552 + \frac{m}{\sqrt{R}}}$$

values of m being the same in metric and English systems. Since any one of the four quantities V, R, S or m may be the unknown, to facilitate the mathematical work involved the following diagram based on the theory of isopiethe points was devised. This theory being discussed in various textbooks, mention having also been made of it in Engineering News before this, it is hardly necessary to describe the mode of construction. It is sufficient to say that by taking suitable factors in determining the scales of the diagram, a chart of any desired size may be obtained.

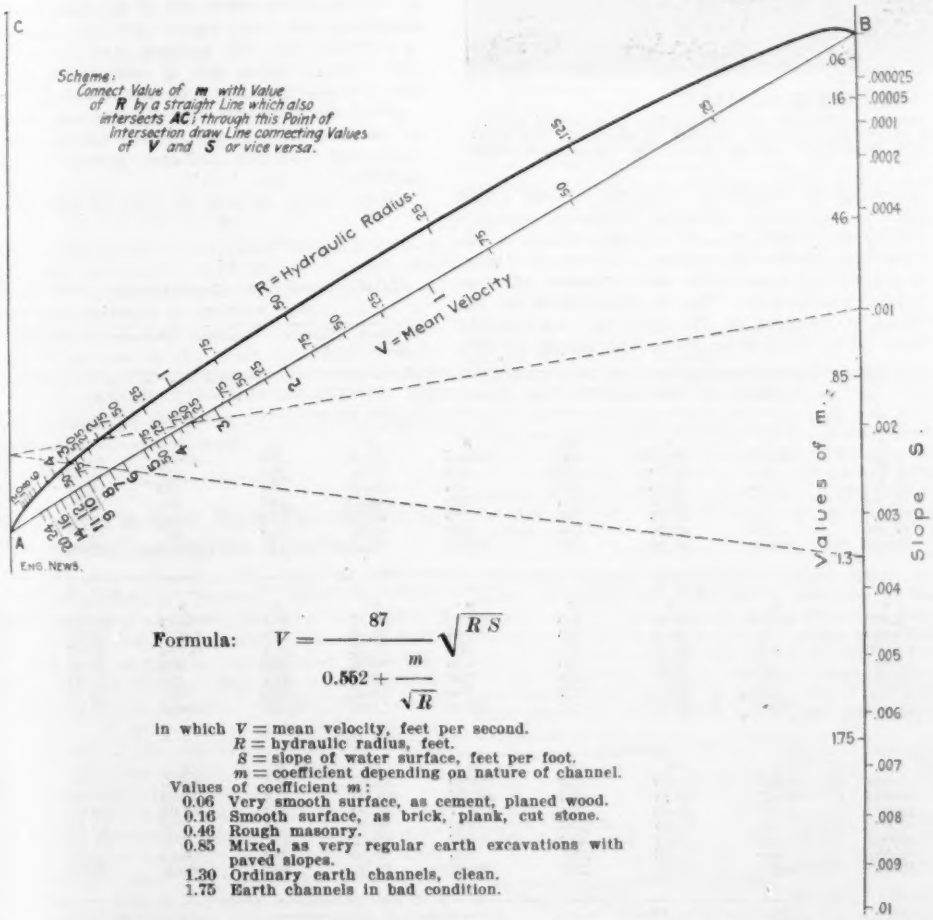
Naturally the value of V determined by use of Kutter's formula for c is not the same in all cases as the V found by using Bazin's formula. This is not surprising since both are empirical formulas derived from different sets of experiments.

Bazin's formula is used throughout Europe. It can at any event answer as a good check on Kutter's values.

In case only one of the four terms is known, by proper shifting of straight edges any number of solutions may be obtained of which the most suitable one may be selected.

Sincerely yours,
O. von Voigtlander.

Union College, Schenectady, N. Y., March 23, 1909.



Formula: $$V = \frac{87}{0.552 + \frac{m}{\sqrt{R}}}\sqrt{RS}$$

in which V = mean velocity, feet per second.
R = hydraulic radius, feet.
S = slope of water surface, feet per foot.
m = coefficient depending on nature of channel.

Values of coefficient m:

0.06	Very smooth surface, as cement, planed wood.
0.16	Smooth surface, as brick, plank, cut stone.
0.46	Rough masonry.
0.85	Mixed, as very regular earth excavations with paved slopes.
1.30	Ordinary earth channels, clean.
1.75	Earth channels in bad condition.

DIAGRAM FOR BAZIN'S FORMULA FOR FLOW IN OPEN CHANNELS.

How May Engineers be Branded?

Sir. I have read with interest the "Letters to the Editor" in your issue of March 25, relating to "Engineering: A Profession" and "Pay of Engineers."

It seems to me that the first step in the solution of the problems involved is to determine just what qualifications a man must possess in order to be classed as an engineer.

I have just had personal knowledge of an instance where a man with no technical training and no engineering experience beyond making a claim to the title of "engineer" secured a commission to take charge of an important engineering project for a city, and the city seems to be "in bad" because it is claimed that, in Massachusetts at least, there is no way of determining what really constitutes an engineer.

As long as the title of engineer can be assumed by any one who has the necessary "nerve," engineering will not be a profession or even a well-paid trade.

If, before a man could hold himself out to the public as an engineer, he were required to qualify in a similar manner as is required of a man before he can practice law in the courts, the questions of dignity and compensation would largely settle themselves.

I realize that the work of determining just how to "standardize" the engineer is not easy, but I think that Engineering News can do much to accomplish a practical solution of these problems.

Yours very respectfully,
Edwin F. Dwelley.

31 Exchange St., Lynn, Mass., April 7, 1909.

[We fear our correspondent overestimates both our ability to solve knotty problems and the power of statutory regulations to raise professional standards. Notwithstanding the restrictions upon entrance to the professions of law and medicine, there are many incompetent doctors and crooked lawyers in active practice. We believe more can be done by the engineering profession itself to raise its standards and protect the public from incompetent engineers than by any other means. If every engineer of high or low degree were to realize that it is his duty to the profession and his duty as a citizen to use all his influence in support of sound engineering and competent engineers and his duty also to condemn all cases of incompetence and lax professional standards in engineering work—if engineers themselves would do this, they could effect a great deal for the benefit of their profession and the public.—Ed.]

A VALUATION OF $14,400,000 has been placed upon the works of the Denver Union Water Co. by the engineering board of appraisers appointed some time ago for this purpose. The sum named is made up as follows: $10,354,075 for the physical plant; $2,845,925 for water rights; $1,200,000 for "business and going concern value." Portions of the works valued at $315,000 are owned by the city of Denver. The valuation of the physical plant is defined in the report as

> including all land and all structures, based on the fair cash value of the land and the fair and reasonable cost of reproducing the structures, including allowances for interest during construction, engineering, contingencies and general expenses, and with due deductions for the depreciation because of wear and tear, and allowances for increase or decrease in utility and value for the purpose for which they are used.

The report is signed as approved in all particulars by Messrs. M. L. Holman, John R. Freeman, C. L. Harrison and Allen Hazen, and is further signed as approved in all matters save water rights valuations by Mr. Frederick P. Stearns.

A CITY FORESTER FOR CHICAGO is authorized by an ordinance enacted by the City Council in March, 1909. The same ordinance gives the Special Park Commission of Chicago

> full power and authority over all trees, plants and shrubs planted and to be planted in the streets and public highways of the city of Chicago, including the right to plant new trees and to care for the same.

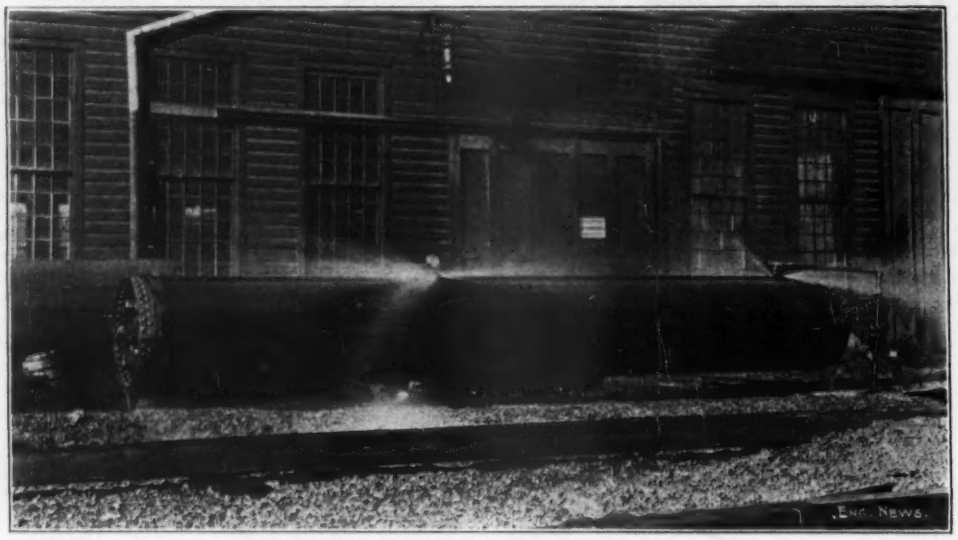
Other powers relating to trees are also vested in the ordinance. The salary of the forester is fixed at $2,000 a year, and he is required to give a bond of $5,000 for the faithful performance of his duties. The ordinance prohibits the planting of trees in Chicago hereafter within 25 ft. of each other, except on written permit from the City Forester, and at a distance less than 2 ft. from the established sidewalk line of the street. Two sections of the ordinance are worth quoting in full, as follows:

> No shade or ornamental tree, plant or shrub shall be planted in any of the streets or public highways of the city of Chicago until the City Forester shall have first approved the kind or variety thereof and designated the location therefor and granted a permit for planting the same.
>
> No person, firm or corporation owning, maintaining or operating any gas pipes or mains laid beneath the surface of any street, alley or public place in the city of Chicago shall permit any leak to occur in such pipes or mains within a radius of 40 ft. of any tree now or hereafter growing in any street or public place in said city, and in the event that a leak exists or occurs in any such pipe or main, it shall be the duty of the person, firm or corporation owning or operating such defective pipe or main to repair the same immediately and stop such leak in a manner so as to prevent a recurrence of the same after receiving a notice in writing from the City Forester calling the attention of such person, firm or corporation to the fact that such leak exists or has occurred and if such person, firm or corporation fails within five days after the receipt of such notice to stop such leak in a manner so as to prevent a recurrence thereof, such person, firm or corporations shall be subject to the payment of a fine of not less than $5 nor more than $100, and a separate offense shall be regarded as committed after each day during which such person, firm or corporation shall continue such violation.

Another section is designed to regulate the paving of the space directly around trees in such a manner that water may be admitted to the roots.

An Interesting High-Pressure Test of Large Pipe.

A hydraulic test of 42-in. steel pipe carried to a pressure of 1,050 lbs. per sq. in., which means a tension of 50,400 lbs. per sq. in. in the metal, is illustrated by the photograph reproduced herewith. The pipe is for a 12-mile main of the water-works of Springfield, Mass., part of its new supply from Little River. At the time of contracting for this main, Mr. E. E. Lochridge, Chief Engineer, and Mr. Allen Hazen, Consulting Engineer, received bids on cast-iron, wrought-iron, riveted steel, and lock-bar* steel pipe. The makers of the latter claimed a greater carrying capacity than that of riveted pipe, and a 100% joint, and the test was undertaken to demonstrate the latter claim. The contract was let for lock-bar pipe to the T. A. Gillespie Co., of New York City. It was made for them by the East Jersey Pipe Co., Paterson, N. J.



LOCK-BAR STEEL PIPE IN HIGH PRESSURE TEST.

(42-in. pipe, 7/16-in. metal, about 26 ft. long. Max. pressure, 1,050 lbs. per sq. in. The pipe bulged at this pressure, and leaks at inlet and at attachment of pressure-gage prevented further increase of pressure. The pressure corresponding to a tensile stress of 60,000 lbs. per sq. in. would be 1,250 lbs. per sq. in. Photograph taken at about 500 lbs. pressure.)

The Springfield main is 42 ins. in diameter for its entire length, but the thickness of metal is of course varied to suit the head. There are 30,300 ft. of ¼-in. pipe, 19,600 ft. of 5/16-in., 7,900 ft. of ⅜-in. and 3,500 ft. of 7/16-in., a total of 61,300 lin. ft. of pipe. The maximum head on the pipe in service is about 350 ft., corresponding to a pressure of something over 150 lbs. per sq. in. The price bid for the lock-bar pipe, laid and jointed, varied from $6 to $8 per lin. ft., according to thickness, totaling $396,435; including some accessory items the contract price was $419,585. These figures are about 7%, or about $27,000, higher than for riveted pipe. However, the thicknesses specified for riveted pipe were reduced in proportion to the higher joint efficiency of the lock-bar; the total reduction amounted to a price decrease of about $8,000. For equal thicknesses of metal, therefore, the riveted pipe would be about $35,000, or 8¾% cheaper, for the same internal diameter.

For the pressure test the 7/16-in. pipe was selected. It proved to be a difficult matter to attain a high pressure in the test. In the first trial the dished steel heads, held by a 6-in. central tie-rod, bulged and cracked on a radial line. They were replaced by ribbed cast-steel dished heads, 1½ ins. thick, held by four 4-in. tie-rods, the ends of the pipe being cut off to give a new attachment. A second test was run up to 750 lbs. per sq. in., by which time there was enough leakage through the rivet-holes where the heads were riveted into the pipe as to prevent further increase in spite of careful calking. To tighten the joint, a 4 × 1-in. flat steel welded band was fitted around the pipe at either end, just back of the rivets, and shrunk on. With this it was possible to attain a pressure of 1,050 lbs. per sq. in. The test was stopped by leakage at the points where the pressure-gage pipe and the inlet pipe were attached, and it was found that the plates had stretched over 4 ins. in circumference without injury to or leakage along the lock-bar joints. The photograph shows this test when 500 lbs. per sq. in., about half the maximum, had been reached.

The thickness of the test pipe was 7/16-in. The steel is ordinary medium steel. When the new heads were put in, after the first test, two test strips were cut from the waste ends of the pipe, circumferentially, with the lock-bar located at the middle of the strip. These strips, tested in tension, showed: Ultimate strength, 56,500 to 58,500 lbs. per sq. in.; Elastic limit, 31,000 to 34,000; Elongation, 1.7 ins. in 8 ins.; Reduction of area, 55 to 59%. Neither fracture was at the lock-bar. On the basis of 57,500 lbs. ultimate strength of the steel, the test reached 88% of the full strength of the metal, or 97% of the minimum specified strength of metal, without showing weakness or leakage at the lock-bars.

The lock-bar used on this pipe has a web of 9/16-in. between the butt ends of the plate. Its width (circumferential) is 2¼ ins. and its thickness (radial) 2½ ins. The edges of the plate are upset cold to about 13/16-in., entering into rabbets of this width in the lock-bar. There are two lock-bars, 180° apart.

The joints between the lengths of pipe are simple taper joints, of 4-in. lap, held by one ring of rivets. The lock-bar is scarfed down in the lap to make a tight joint.

A short length (1,800 ft.) of 54-in. lock-bar pipe is also being furnished to Springfield, but this is separate from the supply-main above referred to.

*This is the Ferguson lock-bar joint, as used at Adelaide and Coolgardie, Australia. Sections of the lock-bar used there may be seen in Eng. News, June 9, 1898, p. 373, and Dec. 29, 1898, p. 423, respectively.

Constants for Computing Reinforced-Concrete Beams.

By J. NORMAN JENSEN.*

A study of the building laws of various cities, and of the specifications drawn up by leading architects and engineers discloses the fact that there is no uniformity as to the allowable unit stresses in concrete and steel, or as to the ratio of moduli of elasticity of the two materials. About the only things in which these laws do agree is that the tensile strength of the concrete should be neglected, and that the linear variation of stress in the concrete should be assumed.

As a result of this condition of affairs the engineer designing work which is to be done in different cities cannot make use of standard tables or diagrams, but must figure each case separately to conform with the building laws of that city. This means a great deal of labor on his part, as the formulas used are long and unwieldy.

Given the allowable unit stresses and the ratio of the moduli, there are three constants that the reinforced concrete designer wants to know, namely,

(1) p = ratio of area of steel to area of concrete, $\frac{A}{bd}$.

(2) K = coefficient of resistance. Kbd^2 = bending moment = resisting moment.

*Office Engineer, National Concrete Construction Co., Louisville, Ky.

TABLES OF CONSTANTS FOR COMPUTING REINFORCED-CONCRETE BEAMS.

	c = 400 lbs.								
	n = 10			n = 12			n = 15		
s	p	K	x	p	K	x	p	K	x
8,000	.00833	59.26	.333	.00937	65.63	.375	.01073	73.47	.429
10,000	572	51.70	.286	650	57.85	.324	750	65.62	.375
12,500	388	44.56	.242	444	50.36	.277	519	57.89	.324
15,000	281	39.15	.211	323	44.57	.242	381	51.70	.286
16,000	250	37.33	.200	289	42.60	.231	341	49.58	.273
17,000	224	35.68	.190	259	40.81	.220	307	47.63	.261
18,000	.00202	34.16	.182	.00233	39.15	.211	.00278	45.83	.250
	c = 500 lbs.								
	n = 10			n = 12			n = 15		
s	p	K	x	p	K	x	p	K	x
8,000	.01210	83.83	.385	.01340	91.84	.429	.01512	101.56	.484
10,000	834	74.08	.333	.00938	82.03	.375	.01073	91.91	.429
12,500	571	64.62	.286	650	72.32	.324	.00750	82.03	.374
15,000	416	57.29	.250	476	64.62	.286	556	74.11	.333
16,000	372	54.80	.238	426	61.98	.273	499	71.33	.319
17,000	335	52.51	.227	384	59.55	.261	451	68.76	.306
18,000	.00303	50.41	.217	.00348	57.29	.250	.00409	66.34	.295
	c = 600 lbs.								
	n = 10			n = 12			n = 15		
s	p	K	x	p	K	x	p	K	x
8,000	.01613	110.20	.429	.01780	119.67	.474	.01985	130.79	.529
10,000	.01129	98.44	.375	.01257	108.06	.418	.01423	119.66	.474
12,500	.00778	86.78	.324	.00877	96.30	.366	.01002	108.11	.418
15,000	571	77.55	.286	648	86.78	.324	750	98.43	.374
16,000	512	74.38	.273	582	83.47	.310	675	95.04	.360
17,000	460	71.46	.261	525	80.40	.298	611	91.88	.346
18,000	.00417	68.75	.250	.00476	77.55	.286	.00555	88.88	.333
	c = 700 lbs.								
	n = 10			n = 12			n = 15		
s	p	K	x	p	K	x	p	K	x
8,000	.02041	137.92	.467	.0224	148.66	.512	.02480	161.11	.567
10,000	.01440	124.34	.412	.0160	135.47	.457	.01782	148.75	.511
12,500	.01004	110.61	.359	.0112	121.82	.402	.01280	135.46	.457
15,000	741	99.55	.318	836	110.61	.359	.00960	124.38	.412
16,000	666	95.72	.304	754	106.67	.344	869	120.40	.397
17,000	600	92.16	.292	681	102.99	.331	786	116.66	.382
18,000	.00546	88.85	.280	.00619	99.55	.318	.00717	113.15	.369
	c = 750 lbs.								
	n = 10			n = 12			n = 15		
s	p	K	x	p	K	x	p	K	x
8,000	.02270	152.19	.484	.02480	163.49	.529	.02748	176.73	.585
10,000	.01610	137.76	.429	.01775	149.58	.474	.01985	163.70	.530
12,500	.01123	123.05	.375	.01254	135.07	.419	.01423	149.86	.474
15,000	833	111.11	.333	.00936	123.05	.375	.01071	137.97	.429
16,000	747	106.95	.319	843	118.80	.360	.00968	133.61	.413
17,000	676	103.08	.306	764	114.83	.346	879	129.51	.399
18,000	.00613	99.48	.294	.00695	111.11	.333	.00803	125.82	.385

(3) x = ratio of the depth of the neutral axis to depth (d) of steel.

If the bending moment is known the first two constants are sufficient for the complete design of a slab, and the third is needed to show the position of the neutral axis in beams.

In order to arrange the constants for every possible combination of working stresses and of the ratio of the moduli, in a convenient form the following table was prepared. The values given are perhaps carried to a greater degree of refinement than is necessary considering the fact that in actual construction no such refinement is attained, but it was thought advisable to carry the figures to one more place than would be used in designing.

The nomenclature adopted is that used by most writers on reinforced concrete, and in addition to the above is as follows:

c = working stress in concrete at its compressive face.

s = working stress in steel.

n = ratio of the moduli of elasticity, $\frac{E_s}{E_c}$.

b = breadth of beam.

d = distance from the compressive face to the center of the steel.

The formulas used to obtain these constants are based on the theory of the linear variation of the stress in the concrete. These formulas are derived in any standard text-book on this subject, such as Turneaure & Maurer's "Principles of Reinforced-Concrete Construction," and are as follows:

$$p = \frac{1}{\frac{2}{\frac{s}{c}\left(\frac{s}{nc}+1\right)}}$$

$$K = \frac{c^2 n\,(3s + 2nc)}{6\,(s + nc)^2}$$

$$x = \sqrt{2pn + (pn)^2} - pn.$$

The value of "n" is frequently omitted in specifications, as some architects and engineers consider it of no importance. It is of interest to note that a variation of 50% in the value "n" for stresses commonly used, 600 lbs. in the concrete, 16,000 lbs. in the steel, produces a variation of 31% in "p," of 28% in "K," and of 32% in "x."

For values between those shown in the tables interpolation is easily made.

New Records in Hard Rock Tunnel Driving on the Los Angeles Aqueduct.

The Elizabeth Tunnel of the Los Angeles Aqueduct, which in October, 1908, broke the American record of speed for rock tunnel driving,* running 466 ft. in 31 days, has again made a record run, exceeding its previous record by 10 ft. During March, 1909, the south heading of the tunnel was advanced 476 ft. This record was made in gneissoid granite, with Leyner hammer drills, the miners working three 8-hr. shifts. The entire section is excavated from one face. Each shift drills and shoots 25 holes.

During March also, two tunnels (Nos. 27 and 29) on the Jawbone Division, which is the most difficult section on the aqueduct, were each driven 370 ft., with but two shifts working (a 16-hr. day). This is the most rapid tunnel driving with two shifts that has been done on the aqueduct to date. The rock is moderately hard granite and the full face is taken out in the heading. Of the 30 miles of tunnel which are to be excavated on the aqueduct, ten miles have been driven up to the present time. [From J. B. Lippincott, Asst. Chief Engr., Los Angeles Aqueduct, Los Angeles, Cal.]

THE BIRMINGHAM UNION STATION at Birmingham, Ala., was opened with dedication ceremonies on April 6. The improvement cost approximately two millions.

*See Eng. News, Nov. 19, 1908, p. 570.

A CAVE-IN AT A SLATE QUARRY at Granville, N. Y., April 13, crushed and killed five workmen.

A COAL MINE EXPLOSION AT WINDBER, PA., April 9, resulted in the death of seven miners. The explosion followed closely upon the simultaneous firing of six charges of dynamite in the fourth heading. The accident occurred just as the day shift was going off duty, which accounts for the comparatively small loss of life. The shot which caused the larger explosion was fired, however, before all the miners had left the workings. The mine is owned by the Berwind-White Coal Co. and was known as Mine 37.

A FIRE AND EXPLOSION AT LENOX, MASS., April 11, caused the loss of six lives and destroyed four store and office buildings, two dwellings and two other structures in the business section. The property loss is estimated at $250,000. The fire started in the Clifford Bldg., in the basement of which was stored turpentine, paint, oil and dynamite belonging to James Clifford & Sons, hardware dealers. It was in this same building that six people were killed, and their death is ascribed primarily to the series of explosions in the basement which cut off their escape and caused the rapid spread of the flames.

A CONFLAGRATION AT ROCHESTER, N. Y., April 13, started in the Palmer Bldg., a four-story brick structure at the corner of Main and Gibbs Sts., and spread over a wide area. A second fire was started at a distance of nearly a mile by burning embers carried by the high wind. Fifty dwelling-houses were ruined and as many more partially burned, rendering more than one hundred families homeless. The loss is estimated at $500,000.

The New York State Board of Fire Underwriters, in session at Syracuse, had just put an advance of $2.50 per thousand on Rochester insurance rates when news of the fire was received. The increase applies only to the congested business districts.

TWO DAMS WERE DYNAMITED during the past fortnight, one of them for the third time. On March 26, the Mermentau dam, which crosses the Mermentau River, near Crowley, La., was blown to fragments by maliciously placed dynamite. This dam, which was described in Engineering News, Sept. 28, 1905, p. 321, was of timber and included a movable dam and lock, was designed to shut out salt water, at low water, from canals serving as a supply to irrigate rice fields. The cattlemen in the neighborhood claimed that the dam caused the overflowing of their pastures and a bitter fight has been waged for the past five years between the rice and cattle interests, culminating twice before, on Oct. 3, 1905, and July 20, 1907, in dynamite explosions similar to this last one, each of which completely destroyed the structure. It is thought that this time no attempt will be made to rebuild.

On April 1 a concrete dam built by the Chicago, Cincinnati & Louisville R. R. at Bruce Lake, Ind., was blown out by unknown persons. The dam was built across the outlet of the lake and raised its level several feet, providing a large water area for a proposed summer resort. Many of the farmers in the vicinity were opposed to the structure, claiming that it flooded their land and highways. The company proposes to rebuild the dam.

PANAMA CANAL EXCAVATION during March exceeded all monthly and daily records yet made on the Isthmus, with a total of 4,062,632 cu. yds., or a daily average of 150,468 cu. yds. for the 27 working days. The best previous daily average was 136,908 cu. yds. for the 23 days in February, 1909, and the best previous monthly total was 3,487,287 cu. yds. in March, 1908, a month of 26 working days. The record for the past two months follows:

Steam shovels.	March.	February.
Atlantic division	130,311	107,865
Central division	1,906,294	1,546,008
Pacific division	139,877	101,432
Dredging.		
Atlantic division	603,046	577,201
Pacific division	924,388	692,198
	3,763,916	3,024,704
Accessory work outside canal prism.		
By steam shovel	298,716	124,175
	4,062,632	3,148,879

Of this 298,716 cu. yds. recorded under "Accessory work outside canal prism" in March, 182,295 is labeled in the report from the Commission as "Accessory works outside of canal excavation proper," so that it cannot be properly credited against the total estimate of total excavation.

The rainfall during March was 1.10 ins., as against 2.85 ins. in February.

ICE AT NIAGARA FALLS this week caused serious trouble for the second time this year. As noted in Engineering News, March 4, 1909, the first trouble arose because of an ice jam above the falls. This time the ice in Lake Ontario was piled at the mouth of the Niagara River by a heavy wind. On account of unusually low temperature, for this time of year, the ice jam froze solid and backed up the water in the gorge. This ice jam formed on the night of April 7 and by the evening of April 9 the level of the river was 40 ft. above normal. This is 12 ft. above the highest level ever before recorded. Water poured into the station of the Ontario Power Co., and washed out some of the track of the Gorge Route electric road.

A RUNAWAY STREET CAR on the tracks of the Boston Elevated Railway Co., on Washington St., Roslindale, Mass., April 7, crashed into an East Walpole car at the foot of the Washington St. hill. One man was killed and ten others were injured. The runaway was an empty and disabled car which had just been towed up the hill to the car barns. Its brake-rods had been previously disconnected. After being uncoupled from the towing car, the empty started to move back down the hill. A motorman, not knowing of the disconnected brake-rods, jumped aboard and endeavored to set the brakes, afterward jumping from the car when he found he could not check its speed. The car had run more than a mile down the hill when it struck the East Walpole car and is estimated to have attained a speed of 30 mi. per hr.

THE JOHN FRITZ MEDAL awarded to Mr. Charles Talbot Porter, Hon. M. Am. Soc. M. E., in recognition of his early work in steam engineering, was presented on April 13 before a company of distinguished engineers at New York. This was the first ceremonious presentation of this medal and to mark the occasion addresses were made by Dean W. F. M. Goss, Mem. Am. Soc. M. E.; Prof. F. R. Hutton, M. Am. Soc. M. E.; Mr. Robt. W. Hunt, M. Am. Soc. C. E., and by Mr. F. J. Sprague, Past President, Am. Inst. E. E., on the debt of engineering to the high-speed steam engine.

THE PENNSYLVANIA RAILROAD SYSTEM on Dec. 31, 1908, comprised nearly 24,000 miles of track, including second, third and fourth tracks and sidings. The exact figures, as given in the annual "Record" issued by the Pennsylvania R. R. Co., were 23,977 miles of tracks and 11,236 miles of railway line. The states traversed by the Pennsylvania R. R. system contain half the population of the United States. During the year 1908, the company handled 334,429,541 tons of freight, an average of nearly 30,000 tons per mile of railway, and the ton-miles of freight movement aggregated 29,353,934,000, or an average of 2,600,000 ton-miles per mile of railway. The passenger traffic amounted to 3,551,361,000 passenger miles, or an average of 316,008 passengers per mile of railway. During 1908 there were 155 miles added to the system and 405 miles to the total trackage. The system's lines now have 3,326 miles of double track and 784 miles of triple track, while for 564 miles four tracks have been laid.

Personals.

Mr. J. R. Parrott, Vice-President and General Manager of the Florida East Coast Ry., has been elected President to succeed Mr. H. M. Flagler, resigned.

Mr. James N. Wallace, President of the Central Trust Co., of New York, has become President of the Galveston, Houston & Henderson R. R., succeeding Mr. F. P. Olcott.

Mr. E. Flynn, Assistant Superintendent of the Chicago, Burlington & Quincy R. R., at Lincoln, Neb., has been transferred to Omaha, Neb., as Superintendent of the new Omaha division.

Mr. T. H. Croswell, M. Am. Soc. C. E., until recently Principal Assistant Engineer of the Northern Pacific Ry., has been appointed Chief Engineer of the Spokane, Portland & Seattle Ry., with headquarters at Portland, Ore.

Mr. Arthur P. Herbert, M. Am. Soc. C. E., has withdrawn from his position as Superintendent of the Colima division of the Mexican Central Ry. and the jurisdiction of the superintendent of the Guadalajara division has been extended over the Colima division.

Mr. J. V. Neubert, Division Engineer of the New York Central & Hudson River R. R., at Rochester, N. Y., has been made Acting Engineer of Track, Exterior Zone, with headquarters at New York City. He is succeeded as Division Engineer by Mr. W. A. Murray, formerly Supervisor of Track at Canandaigua, N. Y.

Mr. John W. Freeman, Assoc. Am. Inst. E. E., has been appointed Manager of the Pittsburg office of the Sprague Electric Co. to succeed Mr. F. W. Barry, resigned. Mr. Frank Wells Hall has been appointed Manager of the Philadelphia office to succeed Mr. G. Charles Conner, whose death was announced in this column April 8.

Mr. Edward C. Sherman, Assoc. Am. Soc. C. E., Division Engineer, Charles River Basin Commission, Boston, Mass., has been appointed Designing Engineer under Lieut.-Col. H. F. Hodges, Assistant Chief Engineer of

the Isthmian Canal Commission. Mr. Sherman's address will be Culebra, Canal Zone. He expects to sail for Panama April 26.

Mr. Robert Mather, President of the Rock Island Co., has resigned that position to devote his entire time to the financial management of the Westinghouse Electric & Mfg. Co. Mr. R. A. Jackson, First Vice-President of the Chicago, Rock Island & Pacific Ry., has succeeded Mr. Mather as President of the Rock Island Co. Mr. Mather's election to the presidency of the board of directors of the Westinghouse Electric & Mfg. Co. was announced in this column Jan. 28.

Mr. Adolf T. Kroeber, M. Am. Soc. C. E., has resigned his position as Assistant Engineer on the staff of Hering & Fuller, New York, to become Railway Commissioner in charge of the construction and operation of railways in German East Africa, with headquarters at Dar-es-Salaam. Mr. Kroeber received his appointment to his new position from the Secretary of the Colonies of the German Empire. During the past year he has acted as Resident Engineer for Hering & Fuller on the construction of sewage disposal works at Reading, Pa.

Obituary.

George Francis Shaw, an inventor, died April 7 at his home in Dedham, Mass. He was born in 1830 at Augusta, Me. With his brother, Henry F. Shaw, he invented a balanced locomotive which attracted some attention twenty-five years ago.

Levi B. Paxson, Consulting Mechanical Engineer of the Philadelphia & Reading Ry. since 1899, died April 10 at Reading, Pa. He was born in Chester Co., Pa., in 1827, and began his railway career as a brakeman with the Philadelphia & Reading in 1847. Since that time he has been consecutively Master Mechanic, Engineer of Machinery, Superintendent of Motive Power and, finally, Consulting Mechanical Engineer.

Frederic A. W. Davis, President, in the year 1896-7, of the American Water Works Association, died April 9 at the home of his son, Mr. Lewis K. Davis, in New York City. Frederic Davis was born in 1835 at Jackson, Mo., but removed with his parents to Indianapolis at the age of 14 years and entered the employ of the old Indiana National Bank, of which he became President in 1871. At the time of his death he was President of the Indianapolis Water Co., Vice-President of the Manufacturers' Natural Gas Co., and owner of the Martinsville Electric Light & Heating Co.

Mr. William Henry Wahl, Resident Secretary and Editor of the "Journal" of Franklin Institute since 1882, died March 23 in Philadelphia, Pa. He was born in Philadelphia in 1848 and was educated in the public schools of that city and at Dickinson College, where he received the degree of A. B. in 1867. During his attendance at the University of Heidelberg, Germany, he took special courses in chemistry, geology and mineralogy, receiving there the degree of Ph. D. in 1869. From 1871-4 he was engaged as a teacher of science in the Central High School and the Episcopal Academy in Philadelphia. From 1876-8 he was editor of the "Polytechnic Review," Philadelphia, and from 1878-'80 he was Associate Editor of the "Engineering and Mining Journal."

Calvin Brown, Civil Engineer, U. S. Navy, retired, one of the oldest, and at one time most prominent civil engineers of California, died in San Francisco on March 27, 1909. He was born in Roxbury, Mass., March 25, 1816, and had just seen his 93d birthday when he passed peacefully away.

With him we have probably lost the last one of that old school of engineers who began the development of our country when the technical arts were in their infancy and who kept pace with the gigantic progress that was made in all the various branches of our profession in the United States. His professional life began in Boston in 1834, in the office of Mr. Robert H. Eddy, a former student of Colonel Baldwin. At that time civil engineering as a professional calling was but little known in the United States. Mr. Brown refers to this in his memoirs, stating that:

> Probably but a very small number of the public had any notion of the meaning of the term. The class of military engineers of the Army was better known, but considered as exclusively concerned with fortifications and so-called "military roadways." The public works then in existence which had been constructed under the supervision of civil engineers were few in number and, in New England, notably confined to two, or three examples if I may include among them the Middlesex Canal, the others being the Boston Mill dam and the Charleston Navy Yard drydock. It was in the construction of the latter work and through the professional spirit of its able builder, Colonel Loamnie Baldwin, that the school of civil engineering in New England originated. This dry dock had involved a greater range of statical and dynamical principles than any other masonry structure then extant on the continent. It constituted a grand work, exhibiting a perfection of mechanical finish, adaptation and proportion, as well as magnitude, then hardly equaled among similar European objects and no where excelled by structures formed with the same materials. Its exact duplicate was built by the same engineer at the same time at the Norfolk Navy Yard. The uniqueness and extent of these two works, the noble character and genius of their designer and builder, and the encouragement he gave to his assistants and to the students he admitted to his office, presented openings and helps for the attainment of engineering science not often realized by the aspirants thereto. The novelty of these grand displays of constructive knowledge and skill and the offered advantages for securing instruction from so eminent an engineer, brought to Colonel Baldwin an eager class of learners who formed the advanced ranks of a profession before almost unknown, but which the development of the country in its vast system of public improvement soon began to call for.

Under these environments Mr. Brown grew up and developed into a civil engineer. In 1840 he was made an Assistant Engineer at the Portsmouth, N. H., Navy Yard, and with that appointment his career as a federal officer and naval engineer began. At one time he was in charge of the public works of nearly all the naval stations, which he visited in turn, making himself thoroughly acquainted with the needs of the Nation's requirements in that direction.

In 1861 he was detached from the Virginia Navy Yard and ordered to the Mare Island Navy Yard, California, at the beginning of the Civil War, when the uncertainty of the conditions at this far away station made it expedient to send a most tried and loyal officer, one who enjoyed the fullest confidence of the President and the administration. Mr. Brown's life work was done at the Navy Yard, Mare Island, which in its early history developed rapidly into a first-class naval station. His most noteworthy work is the stone drydock erected in the 70's.

With a short interruption, during which he built the locks on the Willamette River, near Oregon City, he served his Government efficiently and faithfully until his retirement in 1881. He lived 28 years longer, most of that time in Seattle, on Puget Sound, where he had gone to seek rest and retirement from his useful and busy life. During the Spanish war he was again placed on the active list, and at his then great age he did duty at a number of naval stations on the Atlantic Coast.

One characteristic of this great and good man was his extreme modesty. More would have been known of him and of his works but for his reluctance to be prominent and exhibit his personality. He came to San Francisco a week before his death. The trip from Seattle and the inclement weather were more than his strength could endure, and here in California, where he had spent the best part of his life, his ashes were reverently disposed by old friends who loved the kind old gentleman for his virtues and his talents.

[Contributed by Otto von Geldern, M. Am. Soc. C. E., Pacific Bldg., San Francisco, Cal.—Ed.]

Engineering Societies.

COMING MEETINGS.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION.
April 27 to 30. Annual meeting at Louisville, Ky. Secy., H. D. Vought, 95 Liberty St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 4-7. Spring meeting at Washington, D. C. Secy., Calvin W. Rice, 29 West 39th St., New York City.

AMERICAN ELECTROCHEMICAL SOCIETY.
May 6-8. Annual meeting at Niagara Falls, Canada. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

AIR BRAKE ASSOCIATION.
May 11-14. Annual meeting at Richmond, Va. Secy., F. M. Nellis, 53 State St., Boston, Mass.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 18-20. Annual meeting at Cincinnati, Ohio. Secy., Richard Moldenke, Watchung, N. J.

AMERICAN RAILWAY ASSOCIATION.
May 19. Annual meeting at New York City. Secy., W. F. Allen, 24 Park Place, New York City.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 25-27. Annual meeting at New York City. Secy., W. H. Merrill, 382 Ohio St., Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 1-4. Annual convention at Atlantic City, N. J. Secy., W. W. Freeman, 29 West 39th St., New York City.

AMERICAN WATER-WORKS ASSOCIATION.
June 8-12. Annual convention at Milwaukee, Wis. Secy., John M. Diven, 14 George St., Charleston, S. C.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 16-18. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 21-23. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 39 Old Colony Bldg., Chicago, Ill.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
June 21-23. Annual meeting at Chicago, Ill. Secy., D. B. Sebastian, C. & E. I. R. R., 327 La Salle Station, Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 23-25. Annual meeting at Detroit, Mich. Secy., P. W. Drew, Wisconsin Central Ry., Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 24-25. Semi-annual meeting at New York City. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 28. Annual convention at Frontenac, N. Y. Secy., Ralph W. Pope, 33 West 39th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 29-July 3. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGI... July 6-9. Annual convention at Bretto... Secy., Chas. W. Hunt, 220 West 57th... City.

MONTANA SOCIETY OF ENGINEERS... ing in Butte, Mont., March 13, a letter de... Operations in Korea and China" was rea... The letter was written by a former me... S. Geological Survey and was accomp... photographs showing crude mining appli... tion and various scenes of historic intere...

AMERICAN INSTITUTE OF MINING ... The meeting to be held next autumn wil... sions at Spokane, Seattle and Salt Lak... through the Yellowstone Park. A special ... bers of the institute will leave Chicag... Sept. 13. Spokane has been selected a ... place of the meeting and most of the s... reading of papers will be held there. The ... have, therefore, ample opportunity to vis... Yukon-Pacific Exposition.

WESTERN SOCIETY OF ENGINEERS.— ... ing held at the society's rooms in Chicago o... A. Bement presented a paper on "The Illinois Coal Field." Illinois is the second-largest coal-producing state, and has produced 650,740,000 tons of coal, representing a value of about $1,626,850,000. Of this total, on a basis of 57% recovery, approximately 280,000,000 tons of coal have been wasted. While only 0.5% of the total coal supply has been exhausted, a large proportion of this supply is not available or suitable for use under present economic conditions, so that the remaining supply of really desirable coal is really only 16% of the total. The state has suffered less than others from large mine disasters, as there is only a small amount of gas generated. In a certain district, however, where the coal gives off considerable gas, there have been some very disastrous results, and in this district also there is great disregard for safety.

The chief cause of explosions is the excessive use of powder; this is on the increase, and threatens to become still more serious unless restrictive measures are enforced. From 1895 to 1908, the consumption of powder per ton of coal increased 100%. The mines operated on the room-and-pillar system produce 84.94% of the output, the long-wall system producing only 15.06%. In the former case, the operation is very wasteful, as the pillars are seldom or ever drawn, it being cheaper to open new territory. The paper dealt at considerable length with the location, character and geological conditions of the several coal seams or beds, and the distribution of the production.

The paper was followed by a long discussion, relating largely to geology and economic conditions. Mr. W. T. Ray (U. S. Geological Survey) suggested the possibility of using an abandoned room-and-pillar mine as a huge gas producer, air being blow down one shaft, and gas exhausted at another shaft. It could be worked slightly below atmospheric pressure to avoid danger from the leakage or escape of gas. Mr. G. S. Rice considered that Mr. Bement's estimate of the amount of coal available was too conservative, and thought there would be a very much larger percentage capable of being worked and meeting the competition of other coal-producing districts. Mr. E. E. R. Tratman (Engineering News) thought that with conditions of increasing demand and decreasing supply there would be developments in methods of economically mining and consuming the coals of inferior grades and from the less accessible beds. He mentioned as examples, the utilization of the small coal formerly deposited as waste in the dumps or culm banks of the anthracite mines, and the washing and re-washing (by successive miners) of the tailings from gold and other mines. Other speakers referred to the work of the U. S. Geological Survey and the University of Illinois in investigating the best methods of burning coal and the possibilities of utilizing coals of various grades for furnace use, in gas producers, and in coke making, etc.

Mr. Paul P. Bird (City Smoke Inspector) spoke in favor of the establishment of a state school of mining, and of its important relation to questions of the proper use and combustion of coal. Mr. Buchanan, Secretary of the Illinois Coal Operators' Association, spoke of the difficulties with the miners, and the control which they exercise over the production. Mr. W. L. Abbott, however, thought that the operators had only themselves to blame for such conditions. Before the miners were organized their hours were long, the conditions of labor were bad, the rates were irregular (and always low), and in many ways the men were subjected to hard treatment. The operators, also, are largely responsible for the wasteful manner in which the mining is carried on, leaving large quantities of coal behind.

On motion of Mr. Bement, it was voted to present to the Illinois State Legislature a resolution asking for the establishment of a school of mining at the University of Illinois, and the appropriation of a fund for its support. The committee as appointed is composed as follows: A. Bement, W. L. Abbott, Isham Randolph, R. W. Hunt and B. J. Arnold.

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